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*EMPLOYMENT OF CHEMICAL AGENTS

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DEPARTMENTS OF THE ARMY, THE NAVY, AND THE AIR FORCE

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CHAPTER 2
CHEMICAL AGENTS

★6. General

The following antipersonnel chemical agents are employed in chemical operations: nerve agents GB and VX; blister agent HD; incapacitating agent BZ; and riot control agents CS and CN. Characteristics and effects of these lethal and incapacitating agents are described in the following paragraphs and are tabulated in appendix II.

7. Nerve Agent GB

This agent acts on the nerve systems of man; interferes with breathing; and causes convulsions, paralysis, and death.

a. Inhalation Effects. Inhaled GB vapor can produce casualties within minutes. For troops engaged in mild activity, the median lethal dosage (LCt_{50}) by inhalation is about 70 mg-min/m^3. As an example, 50 percent of a group of unprotected troops breathing at the rate of about 15 liters per minute and exposed to 70 milligrams of GB per cubic meter of air for 1 minute will probably die if they do not receive medical treatment in time. For troops engaged in activities that increase their breathing rate (para 20), the median lethal dosage can be as low as 20 mg-min/m^3. The median incapacitating dosage of GB vapor by inhalation is about 35 mg-min/m^3 for troops engaged in mild activity. Incapacitating effects consist of nausea, vomiting, diarrhea, and difficulty with vision, followed by muscular twitching, convulsions, and partial paralysis. Dosages of GB less than the median incpacitating dosage cause general lowering of efficiency, slower reactions, mental confusion, irritability, severe headache, lack of coordination, and dimness of vision due to pinpointing of the eye pupils.

b. Percutaneous Effects. GB vapor absorbed through the skin can produce incapacitating effects. Sufficient GB liquid absorbed through the skin can produce incapacitation or death. The effectiveness of the liquid or vapor depends on the amount absorbed by the body. Absorption varies with the original amount of agent contamination, the skin area exposed and the exposure time, the amount and kind of clothing worn, and the rapidity in removing the contamination and/or contaminated clothing and in decontaminating affected areas of the skin.

8. Nerve Agent VX

This agent acts on the nerve systems of man; interferes with breathing; and causes convulsions, paralysis, and death. VX will circumvent the protection afforded by the mask. This agent enters the body primarily by absorption of liquid droplets through the skin, causing delayed casualties. See FM 3-10B or additional information on agent VX and VX munitions.

9. Blister Agent HD

This agent produces casualties by its action on the eyes, skin, and respiratory tract, HD is employed principally to circumvent the protection afforded by the mask. It is used primarily in temperate and hot climates.

a. Vapor Effects.

(1) *In eyes or on skin.* The initial disabling effect of HD vapor on unmasked troops will be injuries to the eyes. Temporary blindness can be caused by vapor dosages as low as 100 mg-min/m^3, which are insufficient to produce respiratory damage or skin burns. However, skin burns account for most injuries to masked troops. The vapor dosages and the time required to produce casualties vary with the

atmospheric conditions of temperature and humidity and with the amount of moisture on the skin. Depending on their severity, skin burns can limit or entirely prevent movement of the limbs or of the entire body.

(2) *By inhalation.* Inhaled HD vapor produces delayed casualties, with the first symptoms usually occurring about 6 hours after exposure. For troops engaged in mild activity, the median lethal dosage of the agent by inhalation is 1,500 mg-min/m^3, and the median incapacitating dosage is 200 mg-min/m^3. It is not practicable to produce lethal dosages of HD in the field. Its usually characteristic odor (garliclike) serves as a warning to troops and may allow them to avoid inhalation of sufficient amount to cause incapacitation. Disabling effects include irritation and inflammation of the respiratory tract, with secondary ulceration and infection. With a dosage higher than 200 mg-min/m^3, the time interval between exposure to HD vapor and occurrence of the first symptoms is less than 6 hours. Small, repeated dosages are likely to be cumulative in effect if received in less than 12 hours.

b. Liquid Effects. Droplets of HD liquid can disable troops by causing blisters on the skin. Deaths among exposed troops occur mainly through secondary infection.

10. Incapacitating Agent BZ

This agent temporarily incapacitates personnel. BZ is used in surprise attack against unprotected troops. It functions as a slow-acting incapacitating aerosol having a nonpersistent effect. BZ enters the body by inhalation of the aerosol and interferes with mental processes that control bodily functions. Normally, complete recovery occurs. See FM 3–10B for additional information on agent BZ and BZ munitions.

★11. Riot Control Agents

These agents produce temporary irritating or disabling physiological effects when in contact with the eyes or when inhaled. Riot control agents used in field concentrations do not permanently injure personnel. When they are used in inclosed places, prolonged exposure to the resulting high dosages can disable personnel for several hours and result in serious physiological reactions. The following riot control agents are employed as aerosols against hostile troops or rioting personnel:

a. CS. This agent instantly irritates the eyes, nose, and throat. CS is the most effective of the riot control agents, even in extremely low concentrations. Its effects on the eyes and respiratory system continue for 5 to 10 minutes after exposure to fresh air. During that time most personnel are incapable of effective action. CS that is inhaled before masking or that is trapped in the mask while it is being put on gives the impression that the mask is leaking. This impression, coupled with such effects as chest tightness, nausea, and a burning sensation of the eyes, may cause poorly trained troops to remove their masks, thereby exposing themselves to additional concentrations of CS or of any other agent used in conjunction with CS.

b. CN. This agent quickly irritates the upper respiratory passages and eyes, causing an intense flow of tears from unmasked personnel within seconds of exposure. As a secondary effect, in high concentrations CN is irritating to the skin and can cause a burning, itching sensation, especially on moist parts of the body. Some individuals experience nausea following exposure. CN is dispersed as a thermally or explosively generated aerosol or as a solution in chloroform (CNC).

★Table I. Chemical Munitions and Delivery Systems

Delivery system	Agent: Type	Agent: Avg wt (lb) agent	Munition	Using service	Employment data: a Maximum range (meters)	b Fuze	c Weapons	Average unit (column C) capabilities !: d Average rate of fire per weapon [2]	e Area coverage (hectares) [3, 4, 5]	f Firing time [6]	g Effects [7]	Reference (para)
4.2-inch motar	HD	6.0	Cartridge, M2A1	ARMY	4,500	PD	4/Sec	50 rds/3 min	5.0	15 min	Casualty-producing vapor (skin)	59
				USMC			(6/Btry USMC)	105 rds/15 min	4.5	15 min	Contamination of troops or terrain.	
105-mm howitzer	GB	1.8	Cartridge, M360	ARMY	11,100	PD	6/Btry	3 rds/15 sec 30 rds/3 min	0.5	TOT	Casualty-producing dosage.	58
	HD	3.1	Cartridge, M60	USMC	14,800 [8]			66 rds/15 min	2.5 2.5	15 min 15 min	Casualty-producing vapor (skin). Contamination of troops or terrain.	59
155-mm howitzer	GB	6.5	Projectile, M121						1.0	TOT	Casualty-producing dosage.	58
	HD	9.7	Projectile, M110	ARMY USMC	14,600 18,000 [8]	PD	6/Btry	1 rd/15 sec 12 rds/3 min 24 rds/15 min	2.5 3.5	15 min 15 min	Casualty-producing vapor (skin). Contamination of troops or terrain.	59
	VX	6.5	Projectile, M121			VT			--------	--------	Contamination of troops or terrain.	See FM 3–10B
8-inch howitzer	GB	15.8	Projectile, M426	ARMY	16,800	PD	4/Btry	1 rd/15 sec 4 rds/3 min	2.0	TOT	Casualty-producing dosage.	58
	VX	14.1		USMC		VT	(6/Btry USMC)	10 rds/15 min	--------	--------	Contamination of troops or terrain.	See FM 3–10B
115-mm rocket launcher.	GB	11.0	Rocket, M55 (THE BOLT)	ARMY	10,600	PD	3/Dir Spt Bn.	45 rkt/lchr/ 15 sec.	--------	15 sec	Casualty-producing dosage.	See FM 3–10B
	VX	10.0									Contamination of troops or terrain.	
762-mm rocket, HONEST JOHN	GB	478.0	Warhead, M190 (M139 bomblets)	ARMY	38,000	MT	4/Bn	2 rkt/hr	--------	NA	Casualty-producing dosage.	See FM 3–10B
Chemical landmine	VX	11.5	M23 mine	ARMY	NA	Variety	NA	NA	--------	NA	Contamination of troops or terrain.	37
	HD	9.9	1-gallon mine									See FM 3–10B
Fighter, bomber, aircraft.	GB	-------	Spray tank, Aero–14B.	USMC		NA		NA	----------------		Casualty-producing dosage.	
	VX	-------	TM U–28B.								Contamination of troops or terrain.	
	GB	152.0	Dispenser, CBU–15/A (bomblets in line).	USAF		Impact					Casualty-producing dosage.	
	BZ	68.0	Dispenser, [SUU–13/A] (CBU–16A/A) (bomblets in line).								Incapacitation-producing dosage.	
	GB	-------	Bomb, MK 116, Mod 0.	USMC NAVY		Impact					Casaulty-producing dosage.	
	GB	220.0	Bomb, MC–1, 750–lb.	USAF	Varies with munitions and loading configuration.	Impact	See FM 3–10B for employment data.	Bomb load varies with type aircraft.	----------------		Casualty-producing dosage.	See FM 3–10B
	GB	110.0	Bomb, MK 94, 500–lb.	USMC NAVY		Impact					Casualty-producing dosage.	

★*Table I. Chemical Munitions and Delivery Systems*—Continued

[1] See paragraph 23 for explanation.

[2] Rate of fire varies with training and experience of gun crews, weather conditions, and number of changes in elevation and deflection required during the fire mission.

[3] One hectare equals 10,000 square meters.

[4] Selected meteorological conditions for GB: Neutral temperature gradient, air temperature above 60° F, and windspeed about 8 knots.

[5] Selected meteorological conditions for HD: Neutral temperature gradient, air temperature above 70° F, windspeed about 8 knots, and dry weather.

[6] TOT fire is recommended for maximum effectiveness; if not practicable see paragraph 58*b*.

[7] A casualty-producing dosage consists of lethal dosages and incapacitating dosages (para 7). For maximum effectiveness in a GB surprise dosage attack, the maximum number of artillery should be used in the minimum period of time to obtain time-on-target (TOT) effects (para 58*b*).

[8] Extended range capability.

Note. The following abbreviations are used in "Fuze" column: PD—point detonating; VT—variable time; MT—mechanical time; NA—not applicable.

and creates a vapor hazard as well as a liquid contact hazard (table II). Contaminated terrain presents a hazard to troops that varies from hours to days depending on the nature of the terrain, local climatic conditions, and type of munition. HD freezes in temperatures below 60° F. and can present a delayed hazard to troops when the temperature rises.

Table II. Duration of Hazard in an HD-Contaminated Area[1]
(Negligible Risk)

Task	Type of Terrain	Approximate Time after Contamination that Prescribed Tasks May Be Safely Performed			
		Wearing protective clothing and masks		Not wearing protective clothing	
		Weather			
		Warm, 16°–27° C. (60°–(80° F.)	Hot, above 27° C. (80° F.)	Warm, 16°–27° C. (60°–80° F.)	Hot, above 27° C. (80° F.)
Traversal[2] (Walking across area, 2 hr or less.)	Bare soil, sand, or short grass.	0	0	Wearing masks[3]	
				36 hr	36 hr
	Low vegetation.	4 hr	2 hr	36 hr	36 hr
	High vegetation, including jungle and heavy woods.	12 hr	6 hr	4 days	2 days
Advance under Fire (Contact with ground, 1 hr; total time in area, 2 hr).	Bare soil or low vegetation.	24 hr	8 hr	Not wearing masks[4]	
				3 days	2 days
	High vegetation, including jungle and heavy woods.	2 days	24 hr	6 days	4 days
Occupation (Without hitting ground, 24 hr.)	Bare soil or low vegetation.	1 hr	1 hr	4 days	3 days
	High vegetation, including jungle and heavy woods.	1 hr	1 hr	4 days	3 days
Occupation (Involving advance under fire, 24 hr).	Bare soil or low vegetation.	24 hr	8 hr	4 days	3 days
	High vegetation, including jungle and heavy woods.	2 days	24 hr	6 days	4 days

[1] Based on an average expenditure of 240 to 1,200 pounds of HD per hectare (10,000 square meters).

[2] For men wearing protective clothing, when traversal is made in daylight and areas of heavy contamination can be avoided or decontaminated, the times can be reduced to about one-half of those given.

[3] For men walking in a contaminated area for 2 hours without protective clothing, the limiting factor is the vapor hazard. If the traversal requires only a few minutes, it can be accomplished at earlier times than those given.

[4] The approximate times at which troops could occupy areas without having to wear masks apply to men with or without protective clothing. The vapor hazard is the limiting factor.

72. Downwind Vapor Hazard

Chemical agents present a vapor or an aerosol hazard to troops for a predictable distance downwind of the munitions impact area. The actual downwind distance covered by the toxic clouds will depend on the type and amount of agent disseminated on the target, method of dissemination, meteorological conditions, contour of the terrain, and wind speed and direction.

a. GB Hazard. Refer to appendix IV for a method of estimating the downwind hazard area from GB vapor and to appendix V for an example of a downwind hazard prediction message. Vapor dosages less than 5 mg-min/m^3 are a *negligible* hazard.

b. HD Hazard. Refer to table III for estimation of the downwind hazard distance from HD vapor. Except under unusually favorable meteorological conditions, the downwind vapor hazard is not significant. Vapor dosages less than 25 mg-min/m^3 are a *negligible* hazard.

c. VX Hazard. Refer to FM 3–10B for estimation of VX vapor hazard. The downwind vapor hazard is comparable to that for HD.

Table III. Downwind Vapor Hazard from HD
(To Negligible Risk Level)

Type of Terrain[1]	Downwind Dimension of Target Area (in meters)	Distance Downwind of HD-Contaminated Area that Vapor Hazard May Exist (in meters) [2, 3, 4]	
		Hot, humid weather above 27°C. (80° F.)	Warm weather 16°–27° C. (60°–80° F.)
Open Grassland	200	900	1,600
	500	2,200	4,100
Barren Soil or Sand	200	1,100	2,100
	500	2,700	5,200

[1] For wooded terrain, multiply the above "open grassland" distances by 0.5.

[2] These distances apply only over relatively flat terrain, unobstructed by any breaks due to the presence of trees or houses or abrupt changes of contour of the land.

[3] Distances are based on HD ammunition expenditures given in tables XIV and XV and are measured from the downwind edge of the target area. The time at which 50 percent of the contamination will have evaporated is given in table XV.

[4] Stability conditions favorable to extensive downwind travel are rarely found at high temperatures because the atmosphere under these conditions tends to diffuse and dissipate the toxic cloud before it has a chance to travel a considerable distance downwind of the target area. HD freezes at temperatures below 60° F.; consequently, there is little vapor hazard under cold climatic conditions.

73. Delivery System Error

All weapon systems have a probable error in the accuracy of delivery. When chemical agents are to be delivered close to friendly troop dispositions, this error must be considered in order to prevent the inadvertent delivery of a chemical agent on friendly troops. This degree of expected error is generally small for cannon artillery but of significant size for rockets, missiles, and air-delivered munitions. Delivery error is obtained primarily from appropriate firing tables but can also be obtained from the delivery unit. For troop safety purposes, the minimum safe distance from the munitions impact area is 200 meters plus 3.5 times the largest probable error, or 2.5 CEP's.

74. Commander's Risk Criteria

Because of the toxicity of nerve agent vapors and aerosols, the commander must decide the degree of risk that he will accept for unwarned friendly troops downwind of the target area. Risks are defined in terms of effects that can influence unit effectiveness. The following criteria are used as a guide for establishing the degree of risk for exposure of unmasked friendly troops (table IV):

a. Negligible Risk. Troops are reasonably safe though there may be some threshold effects. The combat effectiveness of units will not be impaired.

b. Moderate Risk. Anticipated effects are tolerable or, at worst, a minor nuisance. There may be a few mildly incapacitated casualties and a slight reduction in unit combat effectiveness, but units will be able to perform assigned missions.

c. Emergency Risk. Anticipated effects may cause some casualties and may significantly reduce the unit's combat effectiveness.

APPENDIX XIII
CHEMICAL AMMUNITION EXPENDITURE TABLES

General

Chemical ammunition expenditure tables (VI–VIII and XI–XV) for unclassified GB weapons and HD weapons are included in this appendix. See chapter 7, section I, for an explanation of the use of these tables, appendix XIV for examples, and paragraph 67 for information on converting area coverage into percentage of GB casualties expected.

Table VI. GB Ammunition Expenditures for the 105-mm Howitzer [1]
(Cartridge M360, PD fuze)

Temperature gradient	Wind speed (knots)	Rounds per hectare for 50-percent coverage [2] of a target area with a casualty-producing dosage [3] (Against troops in open or lightly wooded terrain)[4]					
		Surprise dosage attack [5]			Total dosage attack		
		0°–30°F	31°–60°F	Above 60°F	0°–30°F	31°–60°F	Above 60°F
Lapse	3	79	73	66	9	7	6
	5	37	31	28	14	11	9
	8	36	24	18	20	17	14
Neutral	3	38	33	32	2	2	1
	5	22	18	16	5	3	2
	8	22	12	11	9	6	5
	14	39	17	13	19	12	9
	28	73	37	24	42	27	20
Inversion	3	29	25	22	1	1	1
	5	19	15	13	2	1	1
	8	20	11	8	5	3	2

[1] Weapon rate of fire (6 wpns/btry); 3 rds/15 sec; 30 rds/3 min; 66 rds/15 min.
[2] For 30-percent coverage, multiply by 0.7. For 80-percent coverage, multiply by 1.6.
[3] See paragraph 67 for estimate of casualties.
[4] For jungle or heavily wooded terrain, use data for a 3-knot wind speed.
[5] TOT fire is recommended for maximum effectiveness; if not practicable see paragraph 58b.

★*Table VII. GB Ammunition Expenditures for the 155-mm Howitzer* [1]
(Projectile M121, PD fuze)

Temperature gradient	Wind speed (knots)	Rounds per hectare for 50-percent coverage [2] of a target area with a casualty-producing dosage [3] (Against troops in open or lightly wooded terrain)[4]					
		Surprise dosage attack [5]			Total dosage attack		
		0°–30°F	31°–60°F	Above 60°F	0°–30°F	31°–60°F	Above 60°F
Lapse	3	20	19	17	3	2.5	2.5
	5	11	9	7	5	4	3
	8	13	8	6	8	7	5
Neutral	3	10	9	9	1	1	1
	5	6	5	5	1	1	1
	8	6	5	3	2	1.5	1
	14	10	5	3	5	3	2
	28	22	10	5	11	7	5
Inversion	3	9	7	6	1	1	1
	5	5	4	4	1	1	1
	8	5	3	2	1	1	1

★[1] Weapon rate of fire (6 wpns/how btry): 1 rd/15 sec; 12 rds/3 min: 24 rds/15 min.
[2] For 30-percent coverage, multiply by 0.7. For 80-percent coverage, multiply by 1.6.
[3] See paragraph 67 for estimation of casualties.
[4] For jungle or heavily wooded terrain, use data for a 3-knot wind speed.
[5] TOT fire is recommended for maximum effectiveness; if not practicable see paragraph 58*b*.

Table VIII. GB Ammunition Expenditures for the 8-Inch Howitzer[1]
(Projectile M426, PD fuze)

Temperature gradient	Wind speed (knots)	Rounds per hectare for 50-percent coverage[2] of a target area with a casualty-producing dosage[3] (Against troops in open or lightly wooded terrain)[4]					
		Surprise dosage attack[5]			Total dosage attack		
		0°–30°F	31°–60°F	Above 60°F	0°–30°F	31°–60°F	Above 60°F
Lapse	3	14	14	13	2	2	1
	5	7	6	5	3	3	2
	8	6	4	3	4	3	3
Neutral	3	9	8	6	1	1	1
	5	4	3	3	1	1	1
	8	3	2	1.5	1	1	1
	14	4	2	1.5	2	2	1
	28	9	4	2	5	2	1
Inversion	3	6	6	5	1	1	1
	5	3	3	3	1	1	1
	8	2	1.5	1.5	1	1	1

[1] Weapon rate of fire (4 wpns/btry): 1 rd/15 sec; 4 rds/3 min; 10 rds/15 min. One USMC battery contains 6 howitzers.
[2] For 30-percent coverage, multiply by 0.7. For 80-percent coverage, multiply by 1.6.
[3] See paragraph 67 for estimation of casualties.
[4] For jungle or heavily wooded terrain, use data for a 3-knot wind speed.
[5] TOT fire is recommended for maximum effectiveness; if not practicable see paragraph 58b.

Tables IX and X rescinded

Table XI. ★GB Ammunition Expenditures for the 155-mm Howitzer Battery in the Attack of a One-Hectare or Smaller Target Containing Fortifications with Overhead Cover or Tanks

Temperature gradient	Wind speed (knots)	Rounds per hectare for 50-percent coverage with a casualty-producing dosage				
		Surprise dosage attack [1]				Total dosage attack
		Dosage effects in 15 seconds		Dosage effects in 30 seconds		
		0–30°F [2]	Above 30°F	0–30°F [2]	Above 30°F	0–Above 30°F
Lapse	All [3]	N.S. [4]	36	N.S.	24	15
Neutral	Below 10	N.S.	36	N.S.	24	12
	Above 10	N.S.	36	N.S.	30	24
Inversion	All	N.S.	36	N.S.	24	6

[1] TOT fire is recommended for maximum effectiveness; if not practicable see paragraph 58*b* and *c*.
[2] Snow-covered terrain.
[3] Strong lapse or inversion temperature gradient can be expected only at low to moderate wind speeds, since high wind speeds eliminate stratification.
[4] Not suited. Munition requirements are unacceptably high, or agent cloud cannot be depended upon to develop significant casualties inside fortifications within this time interval.

Table XII. GB Ammunition Expenditures for the 105-mm Howitzer Battery [1] in the Attack of a One-Hectare or Smaller Target Containing Fortifications with Overhead Cover or Tanks

Temperature gradient	Wind speed (knots)	Rounds per hectare for 50-percent coverage with a casualty-producing dosage				
		Surprise dosage attack [2]				Total dosage attack
		Dosage effects in 15 seconds		Dosage effects in 30 seconds		
		0–30°F [3]	Above 30°F	0–30°F [3]	Above 30°F	0–Above 30°F
Lapse	All [4]	N.S. [5]	108	N.S.	60	36
Neutral	Below 10	N.S.	108	N.S.	60	24
	Above 10	N.S.	132	N.S.	72	48
Inversion	All	N.S.	108	N.S.	60	18

[1] Munition expenditures for 105-mm howitzer batteries alone may be considered too high for attack of hard targets. However, 105-mm howitzer batteries can be used to augment fires of higher caliber batteries.
[2] TOT fire is recommended for maximum effectiveness; if not practicable see paragraph 58*b* and *c*.
[3] Snow-covered terrain.
[4] Strong lapse or inversion temperature gradient can be expected only at low to moderate wind speeds, since high wind speeds eliminate stratification
[5] Not suited. Munition requirements are unacceptably high, or agent cloud cannot be depended upon to develop significant casualties inside fortifications within this time interval.

Table XIII. GB Ammunition Expenditures for the 8-Inch Howitzer Battery in the Attack of a One-Hectare or Smaller Target Containing Fortifications with Overhead Cover or Tanks

Temperature gradient	Wind speed (knots)	Rounds per hectare for 50-percent coverage with a casualty-producing dosage				
		Surprise dosage attack[1]				Total dosage attack
		Dosage effects in 15 seconds		Dosage effects in 30 seconds		
		0–30°F.[2]	Above 30°F.	0–30°F.[2]	Above 30°F.	0–Above 30°F.
Lapse	All[3]	N.S.[4]	16	N.S.	12	8
Neutral	Below 10	N.S.	16	N.S.	12	4
	Above 10	N.S.	16	N.S.	16	8
Inversion	All	N.S.	16	N.S.	12	4

[1] TOT fire is recommended for maximum effectiveness; if not practicable see paragraph 58*b* and *e*.

[2] Snow-covered terrain.

[3] Strong lapse or inversion temperature gradient can be expected only at low to moderate wind speeds, since high wind speeds eliminate stratification.

[4] Not suited. Munition requirements are unacceptably high, or agent cloud cannot be depended upon to develop significant casualties inside fortifications within this time interval.

Table XIV. HD Ammunition Expenditures for Vapor Effect
(50-percent coverage of target area)[1]

Rounds required per hectare — 4. 2-Inch mortar (Cartridge M2A1)[3], Wind Speed

Desired effect[2]	Exposure time (hours), Temperature (°F.) 55°	70°	85°	100°	3 knots L	N	I	5 knots L	N	I	8 knots L	N	I	14 knots L	N	I
Cause eye irritation to troops without masks.	1	½	¼	⅛	16	14	10	22	21	11	26	22	15	29	24	20
	2	1	½	¼	9	8	6	14	12	8	16	13	12	24	21	117
	4	2	1	½	8	6	6	10	9	8	13	10	9	20	16	13
	8	4	2	1	6	6	4	9	8	6	11	9	8	15	13	12
	16	8	4	2	5	5	4	9	8	5	10	8	8	13	11	10
Disable masked troops (sweating in humid weather).	1	½	¼	⅛	52	46	35	63	53	39	80	63	46	108	77	59
	2	1	½	¼	33	29	20	40	35	24	56	45	30	69	59	41
	4	2	1	½	24	21	15	33	27	17	42	35	24	65	47	30
	8	4	2	1	18	17	11	26	21	13	38	28	17	63	45	27
	16	8	4	2	16	14	9	22	18	11	33	24	16	58	42	24
Disable masked troops (dry weather).	1	½	¼	⅛	95	83	64	114	95	72	144	113	86	198	144	108
	2	1	½	¼	58	52	36	72	62	44	101	81	57	125	120	71
	4	2	1	½	41	35	26	56	46	30	76	62	45	119	86	57
	8	4	2	1	30	27	18	44	35	23	68	50	32	114	81	50
	16	8	4	2	26	21	13	40	30	18	60	46	29	108	72	42

Rounds required per hectare — 105-MM Howitzer (Cartridge M60)[3], Wind Speed

Desired effect[2]	Exposure time (hours), Temperature (°F.) 55°	70°	85°	100°	3 knots L	N	I	5 knots L	N	I	8 knots L	N	I	14 knots L	N	I
Cause eye irritation to troops without masks.	1	½	¼	⅛	27	24	22	39	34	24	46	44	39	65	53	32
	2	1	½	¼	23	22	18	27	22	20	34	32	29	51	39	26
	4	2	1	½	20	17	16	20	18	17	24	22	20	39	29	22
	8	4	2	1	17	15	12	17	12	13	22	20	15	36	27	18
	16	8	4	2	13	12	10	15	11	10	20	17	12	34	24	15
Disable masked troops (sweating in humid weather).	1	½	¼	⅛	108	83	70	121	95	77	166	123	95	243	157	108
	2	1	½	¼	63	54	42	84	63	47	102	89	66	192	108	82
	4	2	1	½	45	36	27	62	47	32	84	64	48	162	88	64
	8	4	2	1	34	29	18	47	38	24	76	53	33	138	83	54
	16	8	4	2	27	23	15	42	32	18	66	51	30	120	72	48
Disable masked troops (dry weather).	1	½	¼	⅛	174	154	128	212	174	144	...	...	189	...	...	202
	2	1	½	¼	128	98	75	147	113	89	180	156	111	288	198	148
	4	2	1	½	81	64	50	111	86	59	153	118	88	256	165	117
	8	4	2	1	58	50	33	84	65	45	138	95	62	240	154	101
	16	8	4	2	45	39	26	72	56	34	120	84	54	193	132	84

Rounds required per hectare — 155-MM Howitzer and gun (Projectiles M110 and M104)[3], Wind Speed

Desired effect[2]	Exposure time (hours), Temperature (°F.) 55°	70°	85°	100°	3 knots L	N	I	5 knots L	N	I	8 knots L	N	I	14 knots L	N	I
Cause eye irritation to troops without masks.	1	½	¼	⅛	10	10	8	12	11	9	13	12	10	16	14	11
	2	1	½	¼	9	8	6	11	10	8	12	11	9	14	12	10
	4	2	1	½	6	5	4	9	8	6	10	9	8	12	10	9
	8	4	2	1	5	5	4	8	6	5	9	8	6	11	9	8
	16	8	4	2	4	4	4	6	5	4	8	6	5	10	8	5
Disable masked troops (sweating in humid weather).	1	½	¼	⅛	30	28	20	36	32	23	44	39	26	58	46	32
	2	1	½	¼	20	17	12	24	22	15	34	27	18	46	36	24
	4	2	1	½	16	13	10	20	18	11	27	20	15	33	29	18
	8	4	2	1	12	10	6	16	13	9	24	17	12	33	23	16
	16	8	4	2	11	9	5	15	11	8	22	15	11	29	20	15
Disable masked troops (dry weather).	1	½	¼	⅛	53	48	36	63	56	41	78	66	46	105	83	59
	2	1	½	¼	33	28	21	41	36	26	63	54	38	84	66	42
	4	2	1	½	26	21	15	33	28	18	45	36	26	66	50	33
	8	4	2	1	18	16	11	26	21	13	40	33	22	56	42	28
	16	8	4	2	15	12	9	21	18	11	36	30	18	46	36	24

Wind speeds 5 knots and 8 knots: Temperature gradient[4]

[1] For open terrain. For heavily wooded terrain or jungle, multiply the figure obtained by 0.5 to obtain the appropriate expenditure.
[2] See paragraph 69 for estimation of casualties.
[3] Weapon rate of fire:
(4 wpns/sec) 4.2-inch mortar—50 rds/3 min; 105 rds/15 min.
(6 wpns/btry) 105-mm howitzer—30 rds/3 min; 66 rds/15 min.
(6 wpns/btry) 155-mm howitzer—12 rds/3 min; 24 rds/15 min.
(4 wpns/btry) 155-mm gun—4 rds/3 min; 10 rds/15 min.
[4] Temperature gradient abbreviations used are as follows: L—lapse; N—neutral; and I—inversion. Blank spaces indicate excessive expenditures.

Table XV. HD Ammunition Expenditures for Liquid Contamination Effect[1]

A. AMMUNITION EXPENDITURES FOR INITIAL CONTAMINATION
(50-percent coverage of target area)

AMMUNITION	4.2-INCH MORTAR[2]	105-MM HOWITZER[2]	155-MM GUN OR HOWITZER[2]
Number of rounds required per hectare	96	160	42

B. RATE FACTORS TO DETERMINE WHEN TO REPLENISH CONTAMINATION

TERRAIN FACTOR	
OPEN GRASS-LAND	1
FOREST OR JUNGLE	1
BARREN SOIL OR SAND	2

multiplied by

WIND SPEED FACTOR (at 2 meters in the open)	
1 knot	3.1
2 knots	1.8
3 knots	1.3
4 knots	1.0
5 knots	0.8
6 knots	0.7
7 knots	0.6
9 knots	0.5
11 knots	0.4
14 knots	0.3
18 knots	0.3

multiplied by

GROUND SURFACE TEMPERATURE FACTOR	
30° F.	12.5
40°F.	7.0
50°F.	4.0
60°F.	2.5
70°F.	1.6
80°F.	1.0
90°F.	0.6
100°F.	0.4
110°F.	0.3
120°F.	0.2

multiplied by

TEMPERATURE GRADIENT FACTOR (in the open)	
LAPSE	0.7
NEUTRAL	1.0
INVERSION	1.2

EQUALS TIME (HOURS) IN WHICH ABOUT 50% OF CONTAMINATION WILL HAVE EVAPORATED.[3]

[1] For estimation of casualties, see paragraph 69.

[2] Weapon rate of fire:
- 4.2-inch mortar-105 rds/15 min.
- 105-mm howitzer-66 rds/15 min.
- 155-mm howitzer-24 rds/15 min.
- 155-mm gun-10 rds/15 min.

[3] Terrain, wind speed, ground surface temperature, and temperature gradient factors multiplied together give the time (number of hours) in which about 50 percent of the contamination will have evaporated.

[redacted]

S/C

DEPARTMENT OF THE ARMY FIELD MANUAL — FM 3-10B

NAVAL WARFARE INFORMATION PUBLICATION — NWIP 36-4

DEPARTMENT OF THE AIR FORCE MANUAL — AFM 355-9

MARINE CORPS MANUAL — FMFM 11-3B

EMPLOYMENT OF CHEMICAL AGENTS (U)

This copy is a reprint which includes current pages from Changes 1.

[redacted]

[redacted]

DEPARTMENTS OF THE ARMY, THE NAVY AND THE AIR FORCE
NOVEMBER 1966

[redacted]

CHAPTER 1
INTRODUCTION

Section I. GENERAL

1. (U) Purpose

This manual provides classified data on chemical agents and on the capabilities and effects of chemical munitions. When used in conjunction with its unclassified counterpart, FM 3-10/NWIP 36-2/AFM 355-4/FMFM 11-3, Employment of Chemical and Biological Agents, it provides guidance in planning the employment of chemical munitions.

2. (U) Scope

This manual contains classified data on lethal agents VX and GB and incapacitating agent BZ; munitions effects tables; and predicted effects of ground-fired and air-released munitions utilized to disseminate these agents. As a joint publication, it discusses all appropriate chemical munitions of the U.S. Army, Navy, Air Force, and Marine Corps. Unclassified HD chemical munitions expenditure tables and guidance in chemical target analysis and casualty estimation are given in FM 3-10/NWIP 36-2/AFM 355-4/FMFM 11-3.

3. (U) Reliability

Data contained in this manual are based on proving ground tests and field tests, analytical studies of such data, and predictions extrapolated from mathematical models.

4. (U) Army, Navy, Air Force, and Marine Corps User Comments

Users of this manual are encouraged to submit recommended changes or comments to improve the manual. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons for each comment should be provided to insure understanding and complete evaluation. Comments should be forwarded direct to the Commanding Officer, U.S. Army Combat Developments Command CBR Agency, Fort McClellan, Ala. 36205, with an information copy to the cognizant service doctrinal development agency.

Section II. ANTIPERSONNEL CHEMICAL AGENTS

6. ~~(C)~~ (U) Incapacitating Agent BZ

This agent is disseminated as an aerosol to produce physical and mental effects when inhaled. The effects are temporary, and recovery is normally complete. There may be permanent ill effects in a few instances among the very young, the aged, and the infirm, or when massive dosages are received.

a. Tactical Employment. BZ is employed against carefully selected targets to incapacitate enemy troops when the use of lethal or destructive munitions is undesirable. This agent may be particularly useful in situations where adequate protective equipment is normally not available to enemy troops or where the status of training or mask discipline is poor, such as in counterinsurgency operations.

b. Limitations. BZ has the following limitations:

(1) The white agent cloud produced by pyrotechnic mixtures acts as a visible alarm.

(2) BZ may be defeated by improvised respiratory protection such as a folded cloth over mouth and nose.

(3) The effects are not immediate but require an average onset time of about 3 to 6 hours.

(4) There is no known antidote to treat affected friendly personnel.

c. Median Incapacitating Dosage (ICt_{50}). This is about 110 mg-min/m³ for man engaged in mild activity (breathing rate of 15 liters/min).

d. Physiological and Psychological Symptoms. The symptoms listed below will become more intense as the dosage received increases. They also vary according to the inherent characteristics of each individual exposed to the agent. Because of the many variables involved, estimation of the percentage and type of casualties produced from a BZ attack is difficult. Approximations for the occurrence of ultimate casualties among unmasked personnel are 5 percent in 2 hours, 50 percent in 4½ hours, and 95 percent in 9½ hours.

(1) Symptoms likely to appear in 30 minutes to 3 hours: dizziness, extreme drowsiness, dryness of the mouth, and increased heartbeat.

(2) Symptoms likely to appear in 3 to 5 hours: restlessness, involuntary muscular movement, near vision impairment, and physical incapacitation.

(3) Symptoms likely to appear in 6 to 10 hours: hallucinations, lack of muscular coordination, disorientation, and difficulty in memory recall.

e. Duration of Incapacitation. The duration of incapacitation varies with the dosage received—from 24 hours to 5 days.

f. Duration of Effectiveness. Under average meteorological conditions in the open, the aerosol is normally effective for only a few minutes after dissemination, since the fine BZ particles travel

[redacted]

27. (U) CBU-5B/M43 750-Pound BZ Cluster Bomb

Both the U.S. Air Force CBU-5B and the U.S. Army M43 750-pound cluster bombs contain 57 M138 BZ-filled bomblets. The U.S. Army M43 cluster is designed for delivery by aircraft at low speeds. When modified and equipped with a suitable fairing for streamlining purposes, an internal arming wire system, and a strengthened tail fin, it is then designated the CBU-5B and can be delivered by high-performance aircraft.

a. Operational Concepts. The BZ cluster bomb is used on carefully selected targets against enemy personnel when the use of lethal chemical or destructive weapon systems is militarily or politically undesirable. See paragraph 6 for additional data.

b. Characteristics. The cluster contains about 85 pounds of agent BZ and employs two tail mechanical time fuzes. To function properly, the cluster must be released above 6,200 feet so as to allow the cluster to open at approximately 4,500 feet. The M138 bomblet contains four canisters, each with three-fourth pound of agent-pyrotechnic mixture (50/50 ratio), and an "all-ways" impact fuze. The bomblet is *not* self-dispersing.

c. Capabilities. The cluster delivers M138 bomblets over an elliptical impact area having a cross section of approximately 100 by 200 meters when released at heights above 6,200 feet. One cluster can cover about 12,000 square meters (1.2 hectares) with an incapacitating total dosage of BZ (110 mg-min/m^3) under neutral temperature gradient and in a wind speed between 2 and 10 knots; under lapse temperature gradient conditions, the area coverage will be smaller. Under optimum delivery conditions, the area coverage for one cluster is expected to range from 15,000 to 20,000 square meters. Field tests indicate that wind speed has only minor effects upon area coverage.

d. Operational Considerations. Refer to the appropriate technical order/flight manual to determine aircraft loads (see para 16*d*).

[redacted]

USAWC RESEARCH ELEMENT
(Research Paper)

What's Wrong With Gas Warfare?

by

Lt Col Stanley D. Fair
Chemical Corps

US Army War College
Carlisle Barracks, Pennsylvania
8 April 1966

Techniques for employment of war gases have not changed appreciably since World War I: volatile war gases are to be used for surprise effect (i.e., to establish a concentration in the target area before the enemy can mask); and to obtain casualties through poor discipline or defensive equipment by covering large areas and by massive dosages.[2] While these techniques remain valid, they should be limited to the attack of military targets that are far removed from civilian population centers. Examples of such targets are the Japanese island strongholds of World War II, Tarawa and Iwo Jima, and guerrilla areas in Vietnam where the insurgents are isolated and relatively invulnerable to bombing with high explosives. The reasons that current techniques for employment of gas will have infrequent application in modern warfare are:

(1) Unless the target is under close observation or there is excellent intelligence, the protective posture (availability of masks and special clothing) of the enemy will be unknown. The expected results for planning subsequent operations will be in doubt.

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[2]US Dept of the Army, Field Manual 3-10, p. 12.

(2) A sophisticated enemy has modern defensive equipment and can be protected in seconds, if not already protected at the time of the attack. Attempts to "beat" enemy personnel to their masks require large expenditure of war gases and corresponding concentration of delivery means. The risk involved in the exposure of delivery systems to enemy countermeasures is not worth the questionable results.

(3) The variability of surface winds preclude assurance as to where the gas cloud will travel. The military value of downwind drift of the cloud can be negated by automatic gas alarms and good communications. It is highly probable that many civilian casualties will be produced unintentionally because they are unlikely to have masks, ventilated shelters, alarms, and antidotes.

Since military targets in most areas of the world will be near civilian population centers, the primary application of volatile war gases must be as an integrated means of firepower. Volatile war gases should be integrated with high explosive ordnance to the extent that they are used simultaneously. The burst of the high explosive ordnance and gas shells or bombs will be completed instantaneously, destroying or damaging gas protective equipment. Subsequently the gas will spread over the area, achieving an effectiveness greater than if either HE or gas was used alone. The number of gas shells or bombs in the mixed ordnance should be kept small enough so that

lethal effects of the cloud will not extend beyond the target area. Gas used prior to high explosives will be dispersed by the HE detonations and thereby made ineffective. Gas can be used immediately after high explosives, but there must be no delay in the gas attack to permit the enemy to react (use defensive equipment) and lessen his difficult defense problem of simultaneously protecting himself against two widely different threats.

The simultaneous sequence of fires should be carried one step further for large-caliber direct-fire weapons used to attack fortifications and armored vehicles (e.g., recoilless rifles). For gas warfare these weapons should have a gas capsule as an integral part of the munition warhead. This composite munition would utilize its piercing capability to make a hole for the gas to follow through and enter the enclosure. The combined effects of such a munition would greatly increase the "probability of kill" and provide gas an anti-armor role.

Current concepts for the use of non-volatile war gases indicate that they are to be used to contaminate terrain, equipment, and materiel, and to produce casualties or the threat of casualties by their presence.[3] The use of non-volatile war gases to contaminate terrain (except in isolated areas or against an unsophisticated enemy) should be reconsidered. Modern armed forces are highly mobile: helicopters can airlift soldiers over gas obstacles

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[3] _Ibid_.

PUBLIC INFORMATION PROGRAM

A new national policy on gas warfare such as the one presented above can provide the necessary guidance for the people as to the importance of gas weapons and their role. The formulation of policy must precede or accompany any attempt to educate the public on gas warfare since "public knowledge of facts is not understanding until it can be set in the framework of policy and goals."[11]

Public resistance to a new policy may occur because of false impressions about gas warfare. Since the American people have considerable influence on adoption of policy, they must be provided objective information on gas warfare. As "Elihu Root...wrote... when policy on foreign affairs is largely dominated by the people, the danger lies in mistaken beliefs and emotions."[12]

The issue of gas warfare is emotional and political. In this respect it is similar to many issues facing our government today; communism and race relations are examples. Government officials have led the way with free and open discussions on these controversial subjects and should do the same with gas warfare. This leadership is essential, as Major General W.M. Creasy warned a House Science Committee in 1959:

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[11] "Public Understanding--The Ultimate Weapon?" The General Electric Defense Quarterly, Vol. 3, Oct.-Dec. 1960, p. 33.

[12] William Albig, Modern Public Opinion, p. 12.

Albig, William. Modern Public Opinion. New York: McGraw-Hill, 1956. (HM261 A451)

> I do not believe the American people are going to read any information on a subject when the American government says this is too horrible to use and we are not going to use it.[13]

The first step in a public information program is to go after the roots of public hostility towards gas warfare: World War I propaganda. The effects of the Allied propaganda did not evaporate with the gas clouds of World War I "for that half-century-old vision of the blue-faced men at Ypres choking to death, has left an indelible impression upon the mind of the world."[14] As late as 1953 the horrors of the first gas attack were brought out in the memoirs of a war correspondent who served with the Red Cross at Ypres:

> This horror was too monstrous to believe at first... the savagery of it, of the sight of men choking to death with yellow froth, lying on the floor and out in the fields, made me rage with an anger which no later cruelty of man...ever quite rekindled; for then we still thought all men were human.[15]

The tragedy of the first gas attack should be admitted in any program of public information: the soldiers were helpless; those who did not panic and run suffered a slow and painful death. On the other hand, it should be pointed out that protection against chlorine was simple and was achieved before the second gas attack took place two days later. Ypres was an isolated incident.

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[13]Quoted in US Congress, House, Committee on Science and Astronautics, Chemical, Biological and Radiological Warfare Agents, p. 22.

[14]Hanson W. Baldwin, "After Fifty Years the Cry of Ypres Still Echoes--'GAS!'," New York Times Magazine, 18 Apr. 1965, p. 50.

[15]Geoffrey W. Young, The Grace of Forgetting, p. 233.

The best counter to propaganda is to tell the truth. In getting the facts to the public it is important to differentiate between information which can and cannot be made available to the public. They should know in general what is going on, but the details must remain classified to protect national security. It is important also to differentiate between information which should and should not be made available to the public. Articles on gas warfare should pass the test of one criterion before release by the Department of Defense: does it contribute to public understanding of gas warfare, or does it add to the misconceptions of mystery and indecency?

The free and open discussion on nuclear warfare has resulted in the willingness of the responsible American to accept the nuclear weapon as an unpleasant fact, essential to his country's safety. The current secrecy surrounding gas warfare can create a lack of confidence in the capabilities of gas. Captain Liddell Hart told of British tanks developed during World War II that were fitted with special searchlights for blinding the enemy as well as for night firing. This invention was "kept so secret that the commanders in the field regarded them distrustfully and thus repeatedly hesitated to employ such unfamiliar instruments."[19]

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[19] B.H. Liddell Hart, Deterrent of Defense, pp. 86-87.

FM 3-10

DEPARTMENT OF THE ARMY FIELD MANUAL

CHEMICAL AND BIOLOGICAL WEAPONS EMPLOYMENT

HEADQUARTERS, DEPARTMENT OF THE ARMY
FEBRUARY 1962

FIELD MANUAL No. 3-10

HEADQUARTERS,
DEPARTMENT OF THE ARMY
WASHINGTON 25, D.C., *20 February 1962*

CHEMICAL AND BIOLOGICAL WEAPONS EMPLOYMENT

CHAPTER 1

INTRODUCTION

d. Reliability. The data and procedures presented in this manual have been extracted or derived from official studies and from research and development documents. The potential performance of materiel is based on field trial data with simulants and selected live agents and on theoretical calculations and assumptions developed from mathematical models.

3. The Role of Chemical Agents in Military Operations

a. Chemical weapons increase the flexibility of the integrated weapons systems and place at the commander's disposal a highly effective means of conducting antipersonnel operations.

b. In the conduct of military operations involv-

ing chemical weapons, some factors that should be considered are—

(1) The chemical agents discussed herein do not destroy materiel. On the contrary, they allow the physical preservation of industrial complexes, cultural institutions, lines of communications, and other facilities and materiel that may be useful to friendly forces or that merit preservation for political or economic reasons.

(2) Chemical munitions do not produce physical obstacles to maneuver, since they cause minimal destruction, blowdown, rubble, and similar barriers. Agents that produce a persistent effect, however, will create a hazard to friendly troops.

(3) Chemical agents may be employed to produce a variety of effects ranging from harassment to lethality.

(4) Toxic chemical clouds penetrate fortifications and similar structures that are not airtight. PROBLEMMATIC ! ! ! ! ! !

(5) Because of their area coverage effect, chemical agents, used in mass, are particularly effective in attacking targets whose location is not precisely known.

(6) Chemical munitions are particularly effective for producing casualties among dug-in personnel who are not provided with chemical protection. PROBLEMMATIC

(7) Chemical agents increase the flexibility of the entire spectrum of firepower available to the commander.

(8) Chemical agents may be used to follow up and exploit advantages gained by other means.

(9) Because the effectiveness of chemical agents on the target is influenced by the type and quantity of agent employed and by the method of dissemination, meteorological factors, conditions of the target, and protection and training of enemy troops, it is difficult to predict the results of employment accurately.

(10) Chemical agents may produce hazards to friendly forces because of residual contamination and cloud movement.

4. Chemical Agents

a. The following three type-classified chemical agents provide commanders flexibility in their employment of chemicals.

(1) Nerve agent GB is a rapid-acting lethal agent that is used primarily for respiratory effects against unprotected personnel and for surprise attack against personnel having masks available.

(2) Two agents are used in circumventing the protective mask.

(*a*) VX is a slow-acting lethal nerve agent when absorbed percutaneously. If inhaled as an aerosol or vapor, VX acts as rapidly as GB and is more toxic.

(*b*) HD is a slow-acting casualty agent with a limited lethal effect. It attacks the skin in liquid or vapor form and is also effective by inhalation.

b. The following figures describe GB and HD in more detail. Detailed information on VX is contained in FM 3–10A. More comprehensive data on chemical agents are in TM 3–215.

1. Primary use	Nonpersistent, rapid-acting lethal agent used primarily for respiratory effect.
2. Average time to incapacitation	15 minutes after exposure to an incapacitating dosage; for lethal dosages, death in 5 minutes after appearance of symptoms if untreated.
3. Duration of incapacitation	1 to 5 days for return to duty. (30 to 60 days for return to normal blood cholinesterase level.)
4. Signs and symptoms	Tightness of chest, pinpointing of eye pupils, dimness of vision, excessive sweating, drooling; followed by tension, giddiness, tremors, confusion, slurred speech, weakness, convulsions, and death.
5. Physiological effects	Nerve poison; slow detoxification by body (60 days); effects of successive small dosages considered cumulative for short periods of time (weeks).
6. Route of entry	Inhalation; percutaneous entry by liquid or high vapor concentration is unlikely in the field because of the high dosage required.
7. Protection	Mask against vapor; protective clothing against liquid agent.
8. Limitations	Mask offers adequate protection against vapor for trained and warned personnel.
9. Duration of hazard	The area in and around shell or bomb craters will be contaminated and will remain a hazard to unprotected personnel for periods ranging from 6 hours to several days.
10. Physical properties	Clear, colorless, odorless liquid; freezing point minus 56° C (−69° F.); boiling point 147° C (297° F.); evaporates at approximately the same rate as water.

Figure 1. Characteristics of nerve agent GB.

1.	Primary use	To cause delayed casualties by liquid and vapor effect on the skin and eyes and by vapor effect through the respiratory system.
2.	Average time to incapacitation	Eye effect 3 to 12 hours; skin effect 3 to 24 hours.
3.	Duration of incapacitation	Eye effect 1 to 7 days; skin effect 1 to 4 weeks.
4.	Signs and symptoms	Inflammation of eyes; redness of skin; blistering; ulceration.
5.	Physiological effects	Produces blisters and destroys tissues.
6.	Route of entry	Skin absorption of vapor or liquid and inhalation of vapor.
7.	Protection	Mask, ointment, and protective clothing.
8.	Limitations	Limited effectiveness in freezing weather; greater dosages are required for casualty production than are required with GB or VX.
9.	Duration of hazard	36 hours to several days. See figure 2.1d.
10.	Physical properties	Clear oily liquid with garliclike odor; moderately volatile; freezing point 14° C. (57° F.); boiling point 228° C. (442° F.).

Figure 2. Characteristics of blister agent HD.

Times given indicate approximate time after contamination that personnel may operate in the area

Task	Terrain	Protection (Based on expenditures between 240 and 1,200 pounds of HD per hectare): With protective clothing and wearing masks — Temperature: 16°–27° C. (60°–80° F.)	With protective clothing and wearing masks — Temperature: Above 27° C. (80° F.)	Without protective clothing [1] — Temperature: 16°–27° C. (60°–80° F.)	Without protective clothing [1] — Temperature: Above 27° C. (80° F.)
		Hours	*Hours*	*Days*	*Days*
TRAVERSAL [2] (Walking across area up to 2 hr)	Bare soil, sand, or short grass	0	0	[3] 1½	[3] 1½
	Low vegetation	4	2	[3] 1½	[3] 1½
	High vegetation, including jungle and heavy woods.	12	6	[3] 4	[3] 2
ADVANCE UNDER FIRE (Contact with ground, 1 hr; total time in area, 2 hr).	Bare soil or low vegetation	24	8	[3] 3	[3] 2
	High vegetation, including jungle and heavy woods.	48	24	[3] 6	[3] 4
OCCUPATION (Without hitting ground, 24 hr)	Bare soil or low vegetation	1	1	[4] 4	[4] 3
	High vegetation, including jungle and heavy woods.	1	1	[4] 4	[4] 3
OCCUPATION (Involving advance under fire, 24 hr).	Bare soil or low vegetation	24	8	[4] 4	[4] 3
	High vegetation, including jungle and heavy woods.	48	24	[4] 6	[4] 4

[1] For men walking in a contaminated area for 2 hours without protective clothing, the limiting factor is the vapor.
[2] For men with protective clothing, when traversal is made in daylight and areas of heavy contamination can be avoided or decontaminated, the times can be reduced to about one-half of those indicated above.
[3] Wearing masks.
[4] Not wearing masks.

Figure 3. Duration of HD hazard in target area.

Additional micrometeorological characteristics of the zone of operations are obtained through the following methods:

(1) Aerial reconnaissance and observations.
(2) Ground reconnaissance and observations.
(3) Observations of fog, smoke, and dust in the zone of operations.
(4) Field expedient methods for obtaining micrometeorological data in the vicinity of the target area.
(5) Statistical studies of weather in the theater of operations.

b. A suggested format for transmission and recording of basic weather data is illustrated in appendix II. It is emphasized that in chemical target analysis, the weather predictions are required for a period of time after the attack as well as for the time of the chemical attack.

c. Normally, Air Weather Service detachments are stationed at field army, corps and division headquarters. From these sources a target analyst may obtain weather data and weather briefings, or he may request detailed operational and planning forecasts and climatological information.

10. Temperature

The rate of evaporation of chemical agents increases as the temperature rises. High temperatures cause personnel to perspire more freely, thus opening the pores of the skin and accelerating penetration of the skin by the agent. At low temperatures, extra layers of clothing increase the barrier to the skin.

11. Temperature Gradient

The temperature gradient is an expression of the difference in air temperature at two levels. In the United States Army, it is determined by subtracting the air temperature (Fahrenheit) measured one-half meter above the ground from the air temperature 2 meters above the ground. The three characteristic conditions that are associated with the temperature gradient follow:

a. Lapse. A decrease in air temperature with an increase in height is known as a *lapse* condition. Such a condition normally exists on a clear or partially clear day and is characterized by heat turbulence. It is the least desirable condition for chemical operations because of rapid dissipation of agent clouds.

b. Inversion. An increase in air temperature with an increase in height is known as an *inversion* condition. This condition exhibits a minimum of turbulence and usually exists on a clear or partially clear night or early morning. This is the most desirable condition for chemical operations since the agent cloud tends to remain in the cooler layers of the air near the ground.

c. Neutral. A condition intermediate between lapse and inversion is known as a *neutral* condition. Such a condition prevails when there are small differences in temperature at the two levels and usually exists on heavily overcast days or nights, and shortly after sunrise and near sunset.

12. Wind

The wind is also an important weather element affecting the field behavior of chemical clouds. Of the wind characteristics, velocity and direction have greatest influence. Both characteristics are influenced by terrain and temperature gradient.

a. Velocity. Air moving over an irregular surface sets up eddies, or mechanical turbulence. This turbulence is similar to heat turbulence in that it acts to dissipate a chemical cloud. High wind velocities also cause the agent cloud to pass rapidly over the target area, thus reducing the exposure time. Some air movement is desired to blend the individual clouds of agent formed by each shell burst into a uniform cloud covering the target. Ideal wind velocities for chemical operations are 3 to 9 knots (approximately 6 to 16 kilometers per hour). Wind velocities in excess of 16 knots (approximately 30 kilometers per hour) are not suitable for nonpersistent effects.

b. Direction. Wind directs the travel of a chemical cloud. This fact must be considered in the release of an agent for coverage of a particular target and in the determination of the downwind hazard to friendly troops. The wind direction is the direction from which the wind blows and is expressed in terms of azimuth in mils or degrees.

13. Precipitation

Precipitation has an adverse effect on the behavior of chemical agents, since rain will wash away the liquid agent contamination and snow will cover it. Precipitation also washes agent vapors or aerosol clouds from the air and destroys some agents by hydrolysis.

Line	Munition	Agent	Delivery system	User	5 Employment data			
					(a) Range (Meters)		(b)	(c)
					(1) Maximum	(2) Minimum	Error	Fuze (Capability)
1	Shell, M2A1	HD	4.2-inch Mortar	US ARMY USMC	3,930	180	←Obtain from delivery unit or appropriate firing tables→	M8PD
2	Shell, M360	GB	105-mm Howitzer, M2A1, M2A2, M4, M4A2, M52.	US ARMY USMC	11,140	862		M508PD
3	Shell, M60	HD	105-mm Howitzer, M2A1, M2A2, M4, M4A2, M52.	US ARMY USMC	11,140			M51A5PD
4	Shell, M121	GB	155-mm Howitzer, M1, M1A1, M44.	US ARMY USMC	14,950			M508PD
5	Shell, M110	HD	155-mm Howitzer, M1, M1A1, M44.	US ARMY USMC	14,950			M51A5PD
6	Shell, T__(M121)	VX	155-mm Howitzer, M1, M1A1, M44.	US ARMY USMC	14,950			T76E6VT [1]
7	Shell, M122	GB	155-mm Gun, M2, M53	USMC	23,500			M508PD
8	Shell, M104	HD	155-mm Gun, M2, M53	USMC				M51A5PD
9	Shell, Gas, 175-mm	GB	M107 Gun (SP)	US ARMY	31,500	180		
10	Shell, Gas, 175-mm	VX	M107 Gun (SP)	US ARMY	31,500	180		VT-M514A1
11	Shell, T174	GB	8-inch Howitzer, M2, M2A1, M55.	US ARMY USMC	16,930			M51A5PD
12	Shell, T174	VX	8-inch Howitzer, M2, M2A1, M55.	US ARMY USMC.	16,930			T2061 VT
13	Rocket, M55, 115-mm (BOLT)	GB	Launcher, M91	US ARMY USMC.	10,970	2,740		M417PD
14	Rocket, M55, 115-mm (BOLT)	VX	Launcher, M91	US ARMY USMC.	10,970	2,740		T2061 VT
15	Warhead, M79, 762-mm (HONEST JOHN).	GB	Rocket, M31A1C Launcher, M386.	US ARMY USMC.	24,960	8,500		T2075 Mech Time
16	Warhead, E19R2, 762-mm (HONEST JOHN).	GB	Rocket, XM50 Launcher, M386.	US ARMY USMC.	33,830	8,500		T2075 Mech Time
17	Warhead, E19R2, 762-mm (HONEST JOHN).	VX	Rocket, XM50 Launcher, M386.	US ARMY USMC.	33,830	8,500		T2075 Mech Time
18	Warhead, E20, 318-mm (LITTLE JOHN).	GB	Rocket, XM51 Launcher, XM80.	US ARMY USMC.	18,290	3,200 [1]		T2075 Mech Time
19	Warhead, E21, (SERGEANT)	GB	Rocket, Launcher	US ARMY	139 km	50 km	304m	Preset Radar
20	Warhead, E21, (SERGEANT)	VX	Rocket, Launcher	US ARMY	139 km	50 km	304m	Preset Radar
21	Bomb, M34A1, 1000-lb, Cluster	GB	Fighter, Bomber	USAF	Range of Aircraft.		←Obtain from delivery unit→	M152E3 Mech Time
22	Bomb, MC-1, 750-lb	GB	Fighter, Bomber	USAF	Range of Aircraft.			M905BD
23	Projectile, 5"/38, MK53, MOD O	GB	5-inch Gun	US NAVY	16,450			MK29MOD3PD
24	Projectile, 5"/54, MK54, MOD O	GB	5-inch Gun	US NAVY	19,200			MK30MOD3PD
25	Warhead, Rocket, 5" MK40, MOD O.	GB	Launcher, MK 105 Rocket, M40, MOD O.	US NAVY	4,200			MK30MOD3PD
26	Warhead, Rocket, 5", MK40, MOD O.	HD	Launcher, MK 105 Rocket, M40, MOD O.	US NAVY	4,200			MK30MOD3PD
27	Bomb, MK94, MOD O	GB	Fighter, Bomber	US NAVY	Range of Aircraft.			AN-M103A1ND M195 BD (IMPACT).
28	Bomb, M70A1	HD	Fighter, Bomber	US NAVY	Range of Aircraft.			AN-M158ND (IMPACT).
29	Mine, Land, Chemical, M23	VX	N/A	US ARMY	N/A	N/A	N/A	
30	Mine, Land, Chemical, One-Gallon.	HD	N/A	US ARMY	N/A	N/A	N/A	

See notes at end of figure.

Figure 5. Chemical munitions and delivery systems.

5 Employment data—Continued						6 Functioning and physical characteristics of CML munitions				
(d) Time for delivery		(e)	(f)	(g)	(h)	(a)	(b)	(c)	(d)	(e)
(1) Preplanned	(2) Target of opportunity	Organization	Rate of fire per weapon	Height of burst	Diameter (meters) of impact area (single rd) [2]	Weight of munition (kg)	Weight of agent (kg)	Effective weight of agent (kg) [3]	Functioning efficiency of munition (percent)	Agent dissemination efficiency
-----	-----	6 Mort/Plt 8 Mort/Btry	30 Rds/2 min 105 Rds/15 min	GND	16	10.8	2.72	-----	99	
-----	1–3 min	6 How/Btry	6 Rds/½ min 18 Rds/4 min	GND	27	16.1	.739	-----	99	
-----	1–3 min	6 How/Btry	6 Rds/½ min 18 Rds/4 min	GND	11	15.2	1.22	-----	99	
-----	1–5 min	6 How/Btry	3 Rds/½ min 12 Rds/4 min	GND	49	45.9	2.95	-----	99	
-----	1–5 min	6 How/Btry	3 Rds/½ min 12 Rds/4 min	GND	20	42.0	4.4	-----	99	
-----	1–5 min	6 How/Btry	3 Rds/½ min 12 Rds/4 min	20m [1]	-----	45.9	2.95	-----	99	
-----	1–5 min	4 Gun/Btry	2 Rds/½ min 8 Rds/4 min	GND	49	45.9	2.95	-----	99	
-----	1–5 min	4 Gun/Btry	2 Rds/½ min 8 Rds/4 min	GND	22	43.0	5.31	-----	-----	
		4 Gun/Btry	-----	GND	-----	66.8	6.68	-----	-----	
-----	-----	4 Gun/Btry	-----	GND	-----	66.8	6.04	-----	-----	
-----	½–6 hr	4 How/Btry	6 Rds/4 min 10 Rds/10 min	GND	76	97.0	7.12	-----	99	
-----	½–6 hr	4 How/Btry	6 Rds/4 min. 10 Rds/10 min.	20m [1]	-----	97.0	7.12	-----	99	
-----	30 min	36 Lchr/Bn	45 Rkt/Lchr/15 sec.	GND	46	26.4	4.80	-----	99	
-----	30 min	36 Lchr/Bn	45 Rkt/Lchr/15 sec.	20m [1]	-----	26.2	4.54	-----	99	
-----	15 min	2 Lchr/Bn	2/Hr	Variable	Variable	737	177.5	104.8	95	62 percent.
-----	15 min	2 Lchr/Btry	2/Hr	Variable	Variable	568	210	171	95	86 percent.
-----	15 min	2 Lchr/Btry	2/Hr	Variable	Variable	568	210			
-----	15 min	4 Lchr/Btry	2/Hr	Variable	Variable	119	30			
15 min	120 min	4 Lchr/Bn	2/Day	Intervals of 1,524m.	Variable	744	190			
15 min	120 min	4 Lchr/Bn	2/Day	Intervals of 1,524m.	Variable	744	190			
-----	15 min +flight time.	-----	2–6/Ftr. 4–18/Bmbr.	Variable	170	513	89.6	-----	90	
-----	15 min +flight time.	-----	2–6/Ftr. 4–27/Bmbr.	GND	127	322	99.9			
-----	-----	-----	-----	GND	35	25.1	1.47			
-----	-----	-----	-----	GND	40	29.1	2.02			
-----	-----	-----	48 Rkt/Lchr/ 1 min	GND	49	22.9	2.18			
-----	-----	-----	48 Rkt/Lchr/ 1 min	GND	-----	-----	-----			
-----	-----	-----	-----	GND	90	222	49.8			
-----	-----	-----	-----	GND	29	58.0	272			
-----	-----	-----	-----	-----	-----	10.50	5.23			
-----	-----	-----	-----	-----	-----	5.45	4.50			

[1] Estimated.

[2] Instantaneous agent area coverage 30 seconds after detonation.

[3] Values are the product of values given in columns 6(*b*), 6(*d*), and 6(*e*). Since values for 6(*e*) are not available, values for 6 (*c*)cannot be computed at this time.

Figure 5.—Continued

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Agent—GB.
Wind speed—5 knots (approx 9 km/hr).
Temperature gradient—inversion.
Temperature—60° F. (15.5° C.).
Terrain—open, level, scattered vegetation.
Precipitation—none.
Time limitations on the delivery of agent on target—4 minutes or less.
Casualty level desired—20 percent.

Find: Whether or not the mission can be fired with a 105-mm howitzer battery.

Solution:

(*a*) Using figure 11, convert 20 percent casualties among protected personnel to the corresponding casualty level among unprotected personnel. This is 80 percent.

(*b*) Using the "GB (over 30-sec attack)" column of figure 12, determine the total effects components to be 3.21 as follows:

Inversion	1.09
Wind speed, 9 km/hr	1.00
Temperature, 60° F. (15.5° C.)	.12
Open terrain	.30
No precipitation	.70
	3.21

(*c*) Using figure 13, place a hairline between 80 percent on the percent casualties scale and 12 hectares on the target area scale. On the point of intersection on the reference line, pivot the hairline until it intersects 3.21 on the effects components scale. On the munitions expenditure scale, read 12 as the number of 155-mm equivalents required.

(*d*) To find the number of 105-mm rounds required to fire the mission, multiply 12 by a factor of four (obtain this factor from figure 8); the product is 48 rounds.

(*e*) From figure 9, it is evident that one battery of six howitzers can easily fire the mission if no shift of fires is required. Since the target is twice as large as the dispersion pattern of a 105-mm battery (par. 31*c*(3)(*c*) and 41*d*), a shift of fires should be made. Figure 9 gives a time of 30 seconds for shifting of fires. On this basis the battery could fire twenty-four rounds on half the target in a little less than 30 seconds, take 30 seconds to shift fires, and have ample time to deliver the remaining twenty-four rounds on the other half of the target. The firing should be completed in less than 2 minutes.

Munition	Munition expressed in terms of 155-mm chemical equivalents		
	GB	VX	HD
155-mm Shell	1	1	1
105-mm Shell	0. 25	--------	0. 28
8-inch Shell	2. 40	2. 17	--------
4.2-inch Mortar Shell	--------	--------	. 62
175-mm Shell	2. 1	2. 1	--------
M55 Rocket	1. 6	1. 6	--------
M79 Warhead—HONEST JOHN	60	--------	--------
E19R2 Warhead—HONEST JOHN	71	71	--------
LITTLE JOHN	10	10	--------
SERGEANT	65	65	--------
M34A1 1000-lb Cluster	30	--------	--------
MC1 750-lb Bomb	35	--------	--------
5"/38 Gas Projectile (Navy)	. 50	--------	--------
5"/54 Gas Projectile (Navy)	. 68	--------	--------
5" Gas Rocket (Navy)	. 74	--------	--------
500-lb Gas Bomb	17	--------	--------
115-lb Gas Bomb (Navy)	--------	--------	6. 2

Figure 7. Munitions expressed in terms of 155-mm chemical equivalents. (The figures given are an estimate of the number of 155-mm howitzer rounds required to give the same effect as one round of the specified munition. Dissemination efficiency has not been considered.)

Munition	Conversion factor		
	GB	VX	HD
155-mm Shell	1	1	1
105-mm Shell	4	--------	3. 6
8-inch Shell	0. 41	0. 45	--------
4.2-inch Mortar Shell	--------	--------	1. 61
175-mm Shell	. 48	. 48	--------
M55 Rocket	. 61	. 61	--------
M79 Warhead—HONEST JOHN	. 017	--------	--------
E19R2 Warhead—HONEST JOHN	. 014	. 014	--------
LITTLE JOHN	. 098	. 098	--------
SERGEANT	. 016	. 016	--------
M34A1 1000-lb Cluster	. 033	--------	--------
MC1 750-lb Bomb	. 029	--------	--------
5"/38 Gas Projectile (Navy)	2. 00	--------	--------
5"/54 Gas Projectile (Navy)	1. 46	--------	--------
5" Gas Rocket (Navy)	1. 35	--------	--------
500-lb Gas Bomb	. 059	--------	--------
115-lb Gas Bomb (Navy)	--------	--------	. 164

Figure 8. Conversion factors for converting 155-mm munitions to other munitions.

Weapon	Maximum rate (rounds)	Rates of fire for chemical fire missions without shifting or relaying of the piece (rounds)					Estimated time to shift fires
	30 sec	1 min	2 min	4 min	10 min	15 min	
105-mm Howitzer	6	10	14	18	40	60	30 sec
155-mm Howitzer	3	5	7	12	30	40	30 sec
155-mm Gun	2	4	6	8	12	18	60 sec
8-inch Howitzer	1	2	3	6	10	15	60 sec
4.2-inch Mortar	10	16	30 (max)	50	80	105	30 sec
M91 Launcher (M55 Rocket)	45 (15 sec)	Launcher must relocate after firing each ripple.					

Figure 9. Approximate rates of fire for division cannon artillery, mortars, and multiple rockets firing chemical rounds. (Rates of fire for other weapons are given in figure 5.)

If the target personnel had protection available, the following factors would be applied to the percent casualties for unprotected personnel:

Level of protection	*Degradation factors*
Masks in place	0. 05
Masks available, troops well trained	. 10
Masks available, troops poorly trained	. 25

The above are estimates for GB.

Figure 11. Nomogram for conversion of percent GB casualties for protection of personnel in the target area.

Meteorological and terrain conditions	Effects components			
	GB [2] (surprise attack)	GB (over 30-sec attack)	VX	HD
1. *Temperature Gradient*				
Inversion	0. 67	1. 09	1. 89	0. 69
Neutral	. 57	. 69	1. 89	. 54
Lapse	. 30	. 09	1. 89	. 32
2. *Wind Speed (km/hr)*				
0 to 5	. 20	1. 30	0	. 87
6 to 10	. 50	1. 00	0	. 70
11 to 16	. 70	. 70	0	. 60
17 to 26	. 55	. 30	0	. 48
27 to 52	. 30	0	0	0
3. *Temperature (° F.)*				
a. 0 to 39 (−18° to 4° C.)	0	0	0	----------
40 to 79 (5° to 26° C.)	. 12	. 12	0	----------
80 and up (27° C. and up)	. 23	. 23	0	----------
b. 30 to 49 (−1° to 9° C.)	----------	----------	0	0
50 to 69 (10° to 21° C.)	----------	----------	0	. 70
70 and up (22° C. and up)	----------	----------	0	1. 00
4. *Terrain*				
Open, level, scattered vegetation	. 30	. 30	0	. 30
Rugged, mountainous	0	[1] 0	[1] 0	[1] 0
5. *Precipitation*				
None	. 70	. 70	. 70	0
Moderate rain	0	[1] 0	[1] 0	[1] 0

[1] Estimated.
[2] Tentative figures not yet verified.

Figure 12. Effects components.

Note: paragraph 105 on page 82 states that the "safe entry times" after bio attacks are:

NU (Venezuelan equine encephalitis virus), AB (bovine brucellosis), and UL (tularemia): 2 hrs sun or 8 hrs cloudy

OU (Q fever): 2 hrs sun or 18 hrs cloudy

Cloudy conditions also apply to nighttime

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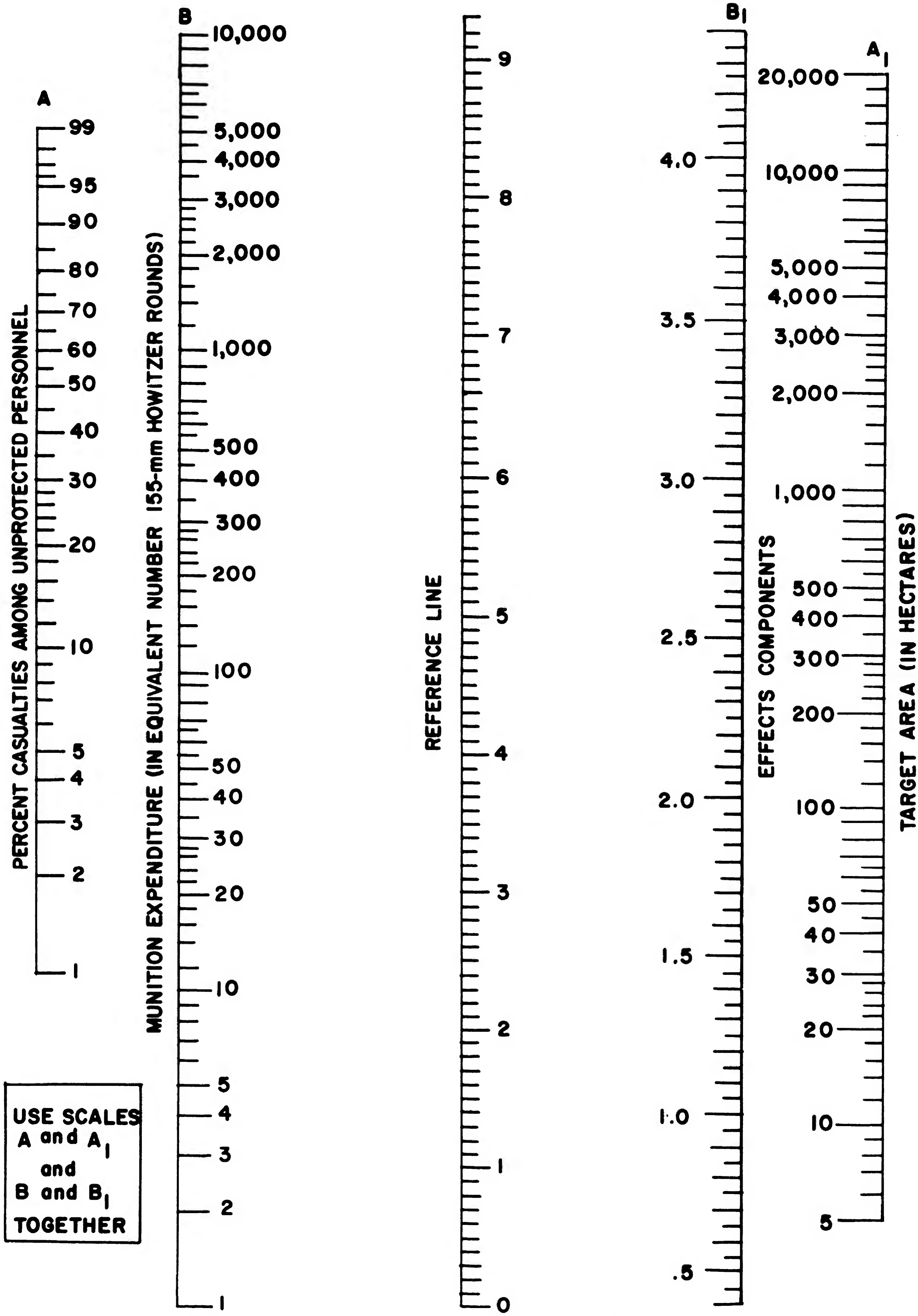

Figure 13. Target area, casualty level, munitions requirement nomogram.

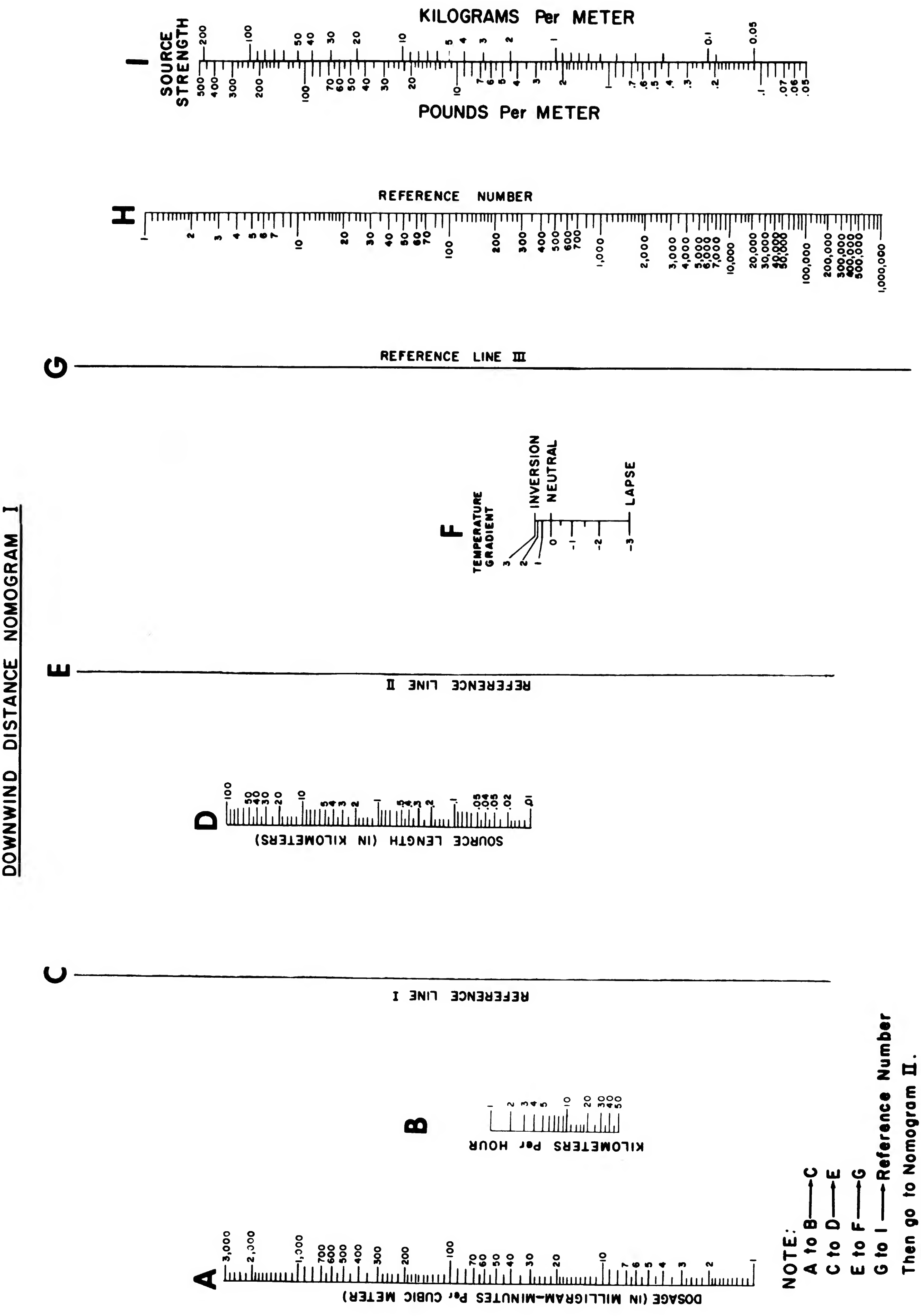

Figure 14. Downwind distance nomogram I.

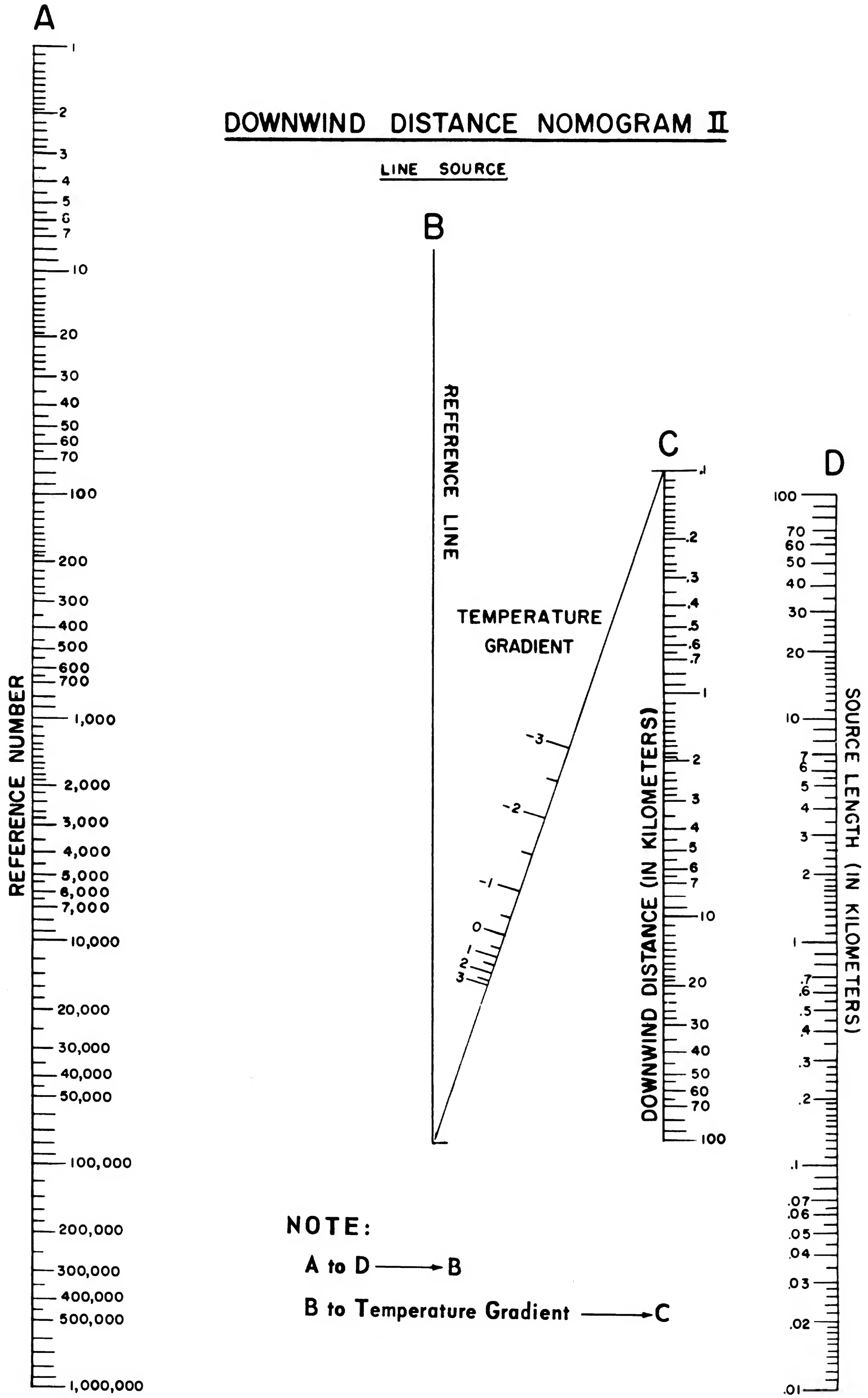

Figure 15. Downwind distance nomogram II.

REFERENCE BOOK

CHEMICAL AND BIOLOGICAL WEAPON EMPLOYMENT

U.S. ARMY COMMAND AND GENERAL STAFF COLLEGE
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CHAPTER 2
TOXIC CHEMICAL AGENTS

1. Characteristics and Effects

a. General. The following antipersonnel chemical agents are used for College instruction in chemical weapon employment: nerve agents GB and VX; blister agent HD (mustard); and incapacitating agent BZ. Actual or assumed characteristics of these agents are described in the following paragraphs for instructional purposes only and are summarized in figure 1.

b. Nerve Agent GB. GB is a quick acting, nonpersistent lethal agent that produces casualties primarily by inhalation.

(1) Inhalation effects. Inhaled GB vapor can produce casualties within minutes. As an example, 50 percent of a group of unprotected troops engaged in mild activity, breathing at the rate of about 15 liters per minute, and exposed to 70 milligrams of GB per cubic meter of air for 1 minute will probably die if they do not receive medical treatment in time. This is the median lethal dosage (50) and is expressed as 70 mg-min/m^3. For troops engaged in activities that increase their breathing rate, the median lethal dosage can be as low as 20 mg-min/m^3. The median incapacitating dosage of GB vapor by inhalation is about 35 mg-min/m^3 for troops engaged in mild activity. Incapacitating effects consist of nausea, vomiting, diarrhea, and difficulty with vision, followed by muscular twitching, convulsions, and partial paralysis. Dosages of GB less than the median incapacitating dosage cause general lowering of efficiency, slower reactions, mental confusion, irritability, severe headache, lack of coordination, and dimness of vision due to pinpointing of the eye pupils.

(2) Percutaneous effects. Percutaneous effects refer to those effects produced by the absorption of the agent through the skin. GB vapor absorbed through the skin can produce incapacitating effects. Sufficient GB liquid absorbed through the skin can produce incapacitation or death. The effectiveness of the liquid or vapor depends on the amount absorbed by the body. Absorption varies with the original amount of agent contamination, the skin area exposed and the exposure time, the amount and kind of clothing worn, and the rapidity in removing the contamination and/or contaminated clothing and in decontaminating affected areas of the skin.

(3) Major considerations in the employment of nerve agent GB. The employment of GB is based primarily on achieving casualties by inhalation of the nonpersistent vapor (or aerosol) of the agent. Major considerations in the employment of this agent are:

(a) Time to incapacitate. The onset of incapacitation resulting from inhalation of casualty-producing doses is rapid, the average time being approximately 3 minutes. To allow for the time required for the agent cloud to reach the individual, 10 minutes is used as the mean time to achieve incapacitation. Nonlethal casualties from GB will be incapacitated for 1 to 5 days.

(b) Persistency. Persistency is defined as the length of time an agent remains effective in the target area after dissemination. Nerve agent GB is considered nonpersistent. GB clouds capable of producing significant casualties will dissipate within minutes after dissemination. Some liquid GB will remain in chemical shell or bomb craters for periods of time varying from hours to days, depending on the weather conditions and type of munition. Because of this continuing but not readily discernible threat, GB can also be highly effective in harassing roles by causing exposure to low concentrations of the vapor. Rounds fired sporadically may compel the enemy to wear protective masks and clothing for prolonged periods, thereby impairing his effectiveness as a result of fatigue, heat stress, discomfort, and decrease in perception.

(c) Level of protection. The weapon system requirements for positive neutralization of masked personnel by GB are too great to be supported except for important point or small area targets. A major factor affecting casualties resulting from GB attacks of personnel equipped with masks but unmasked at the time of attack is the time required for enemy troops to mask after first detecting a chemical attack. Therefore, surprise dosage attack is used to establish a dosage sufficient to produce the desired casualties before troops can mask. Casualty levels for surprise dosage attack that are tabulated in the weapon system effects tables (app A) are based on an assumed enemy masking time of 30 seconds. (Refer to FM 3-10 series manuals for operational data for masking times less than 30 seconds.) A total dosage attack is used to build up the dosage over an extended period of time and is normally employed against troops who have no protective masks available. Dosages built up before troops can mask inside foxholes, bunkers, tanks, buildings, and similar structures will generally be less than dosages attained during the same period of time in the open, thereby reducing the effects on occupants from surprise dosage attacks. Total dosage effects are essentially the same inside or outside.

c. Nerve Agent VX. VX is a slow-acting, lethal, persistent agent that produces casualties primarily by absorption of droplets through the skin.

(1) Effects. VX acts on the nerve systems of man; interferes with breathing; and causes convulsions, paralysis, and death.

(2) Major considerations in the employment of nerve agent VX.

(a) General. Agent VX disseminated in droplet (liquid) form provides maximum duration of effectiveness as a lethal casualty threat. VX will remain effective in the target area for several days to a week depending on weather conditions. Because of its low volatility, there is no significant vapor hazard downwind of a contaminated area. Except when disseminated by aircraft spray tanks, meteorological conditions have little effect on the employment of VX, although strong winds may influence the distribution of the agent and heavy rainfall may wash it away or dissipate it.

(b) Employment to cause casualties. Agent VX is appropriate for direct attack of area targets containing masked personnel in the open or in foxholes without overhead protection, for causing severe harassment by the continuing casualty threat of agent droplets on the ground or on equipment, and for creating obstacles to traversing or occupying areas. Casualties produced by agent VX are delayed, occurring at times greater than 1 hour after exposure. Although this agent can be used relatively close to friendly forces, it should not be used on positions that are likely to be occupied by friendly forces within a few days. Because of this continuing hazard, areas in which agent VX has been used should be recorded in a manner similar to minefields or fallout areas so that necessary precautions can be taken.

d. Blister Agent HD. HD, sometimes referred to as mustard, is a persistent slow-acting agent that produces casualties through both its vapor and liquid effects.

(1) Vapor effects.

(a) The initial disabling effect of HD vapor on unmasked troops will be injuries to the eyes. Temporary blindness can be caused by vapor dosages that are insufficient to produce respiratory damage or skin burns. However, skin burns account for most injuries to masked troops. The vapor dosages and the time required to produce casualties (4 to 24 hours) vary with the atmospheric conditions of temperature and humidity and with the amount of moisture on the skin. Depending on their severity, skin burns can limit or entirely prevent movement of the limbs or of the entire body.

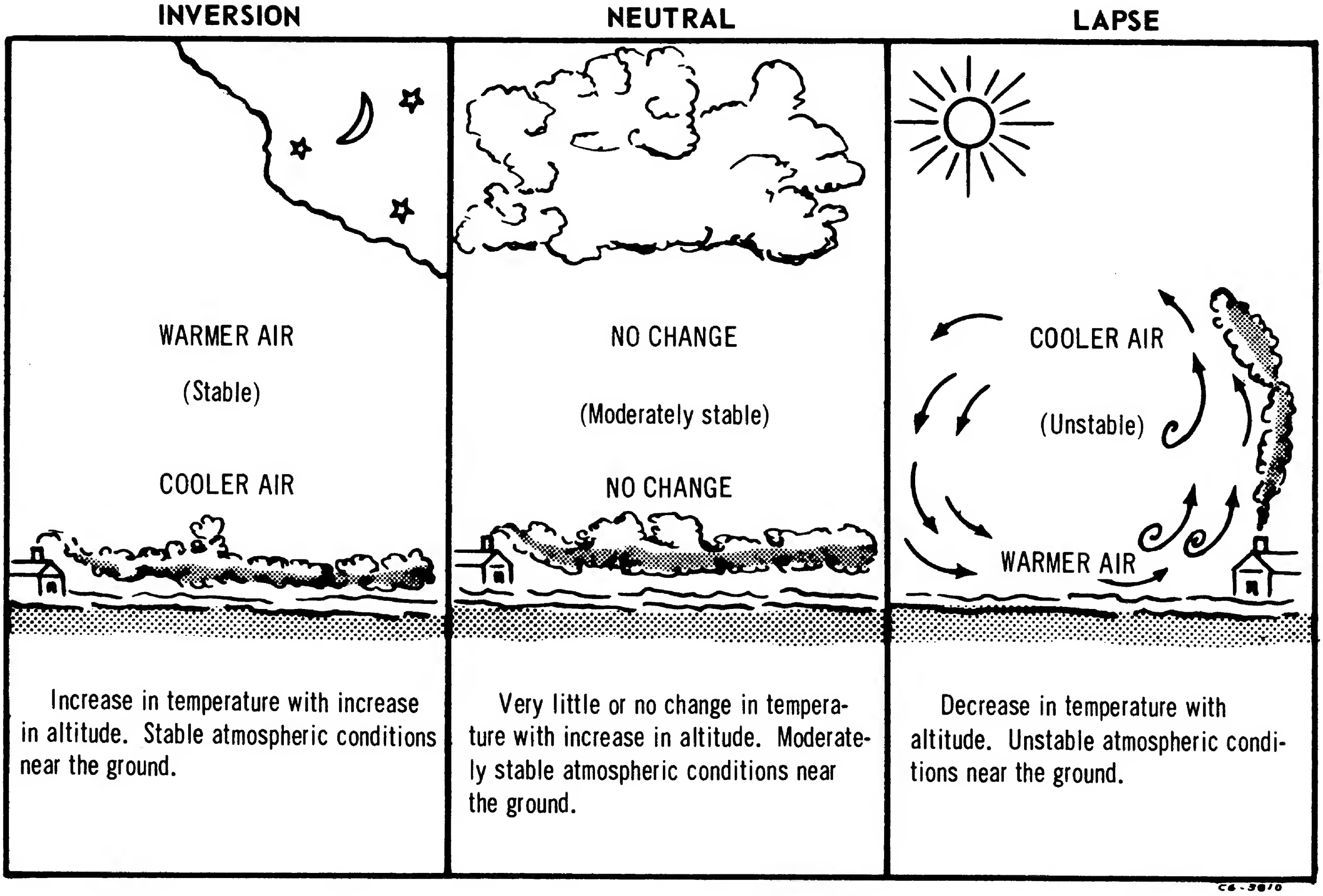

Figure 2. Temperature gradients.

Surprise dosage GB attacks are influenced only slightly by the temperature gradient except when made with the spray tank. Downwind vapor hazards to both enemy and friendly forces will be most significant during inversion and neutral conditions. Employment of VX is not affected by the temperature gradient.

Temperature gradients	Time
1. Inversion	From sunset to sunrise.
2. Neutral	2 hours before sunset to sunset, sunrise to 2 hours after sunrise, or any time windspeed is 15 kmph or greater.
3. Lapse	2 hours after sunrise to 2 hours before sunset.

Figure 3. Estimated times that temperature gradients will prevail. (Use when meteorological data are not available.)

(3) When actual or predicted meteorological conditions are not available for a target analysis, 70° F is used for temperature, 9 kmph is used as windspeed, and the temperature gradient is approximated from figure 3.

d. Windspeed and Direction.

(1) Air moving over the earth's surface sets up eddies, or mechanical turbulences, that act to dissipate a chemical cloud. A condition of calm will limit the merging of the individual gas clouds. Both of these conditions may reduce the effectiveness of a chemical agent attack. High winds increase the rate of evaporation of HD and dissipate chemical clouds more rapidly than low winds. Moderate winds are desirable for chemical employment. Large-area nonpersistent chemical attacks are most effective in winds not exceeding 28 kmph. Small-area nonpersistent chemical attacks with rockets or shell are most effective in winds not exceeding 9 kmph. However, if the concentration of chemical agent can be established quickly, the effects of high windspeed can be partially offset.

CHAPTER 4
EMPLOYMENT OF BIOLOGICAL AGENTS

1. General

a. Antipersonnel biological agents are micro-organisms that produce disease in man. These agents can be used to incapacitate or kill enemy troops through disease. They may cause large numbers of casualties over vast areas and could require the enemy to use many personnel and great quantities of supplies and equipment to treat and handle the casualties. Many square kilometers can be effectively covered from a single aircraft or missile. The search capability of biological agent clouds and the relatively small dose required to cause infection among troops give biological munitions the capability of covering large areas where targets are not precisely located.

b. A biological attack can occur without warning since biological agents can be disseminated by relatively unobtrusive weapon systems functioning at a considerable distance from the target area and relying upon air movement to carry the agent to the target.

c. Biological agents do not produce effects immediately. An incubation period is required from the time the agent enters the body until it produces disease. Some agents produce the desired casualty levels within a few days, whereas others may require more time to produce useful casualty levels. A variety of effects may be produced, varying from incapacitation with few deaths to a high percentage of deaths, depending on the type of agent.

2. Methods of Dissemination

a. The basic method of disseminating antipersonnel biological agents is the generation of aerosols by explosive bomblets and spray devices. Because exposure to sunlight increases the rate at which most biological agent aerosols die and thereby reduces their area coverage, night is the preferable time for most biological attacks. However, if troop safety is a problem, an attack may be made near sunrise to reduce the distance downwind that a hazard to friendly forces will extend. Conversely, to extend the downwind cloud travel and the area coverage from spray attack, a biological agent may be employed soon after sundown.

b. Missile-delivered Biological Munitions. Missile-delivered biological munitions are used for attack of large-area targets. A typical biological missile system consists of the following components:

(1) A missile vehicle and its launching equipment.

(2) A warhead that can be opened at a predetermined height to release biological bomblets over the target area. The warhead is shipped separately for assembly to a missile at the launching site.

(3) A warhead shipping container equipped with a heating-cooling element and a temperature control unit.

(4) Biological bomblets consisting of an agent container and a central burster that functions on impact. The bomblets have vanes that cause them to rotate in flight, thereby achieving lateral dispersion during their free fall and resulting in random distribution as a circular pattern.

c. Aircraft Spray Tank. Biological agents released from an aircraft spray tank cover a large area downwind of the line of release. A typical spray tank consists of the following components:

(1) An agent reservoir section that is shipped separately in an insulated shipping and storage container equipped with a heating-cooling element and a temperature control unit.

(2) A discharge nozzle assembly that can be mechanically adjusted to vary the agent flow rate.

Table 1. Chemical Weapons Data

1	2	3	4	5	6	7	8	9	10	11	12	13
Delivery system	Range (meters)		Agent	Munition	No of weapons per delivery unit	Weapon rate of fire	RT max (meters)[1,2]					Reference (table)
							Fire unit	Total dosage Casualty threat		Surprise dosage Casualty threat		
	Min	Max						10%	30%	10%	30%	
4.2-in mortar	180	4,500	HD	Cartridge, M2A1	4/Plat	50 rd/3 min 105 rd/15 min						18 19
105-mm howitzer		11,100	GB	Cartridge, M360	6/btry	5 rd/30 sec 30 rd/3 min 66 rd/15 min	1 btry[3]	200	100	100	50	2
							1 bn[3]	300	300	200	100	3
			HD	Cartridge, M60								18 19
155-mm howitzer		14,600	GB	Projectile, M121	6/btry	2 rd/30 sec 12 rd/3 min 24 rd/15 min	1 btry[3]	300	200	100	0	4
							1 bn[3]	500	400	300	100	5
			HD	Projectile, M110								18 19
			VX[4]	Projectile, M121			1 btry[3]	400	200	NA	NA	13
							1 bn[3]	500	400			
8-in howitzer		16,800	GB	Projectile, M426	4/btry	1 rd/30 sec 4 rd/3 min 10 rd/15 min	1 btry[3]	300	200	200	0	6
							1 bn[3]	500	400	300	100	7
			VX[4]				1 btry[3]	400	200	NA	NA	14
							1 bn[3]	500	400			
115-mm multiple rocket launcher, M91	2,740	10,600	GB[4]	Rocket, M55 (THE BOLT)		45 rkt/lchr/15 sec	1 lchr	1,000	750	500	200	8
							3 lchr	1,000	1,000	750	400	
							6 lchr	1,000	1,000	1,000	750	
							9 lchr	1,000	1,000	1,000	1,000	
			VX[4]				1 lchr	300	0	NA	NA	15
							3 lchr	750	300			
							6 lchr	1,000	400			
							9 lchr	1,000	750			
762-mm rocket, Honest John	8,500	38,000	GB[4]	Warhead, M190 (M139 bomblets)	2/btry	2 rkt/lchr/hr	1 lchr	600	600	600	400	9
							2 lchr	600	600	600	400	
Sergeant missile	46,000	139,000	GB[4]	Warhead, M212 (M139 bomblets)	2/bn	2 msl/lchr/hr	1 msl	600	400	600	200	10
							2 msl	600	600	600	400	
Aircraft	Dependent on type aircraft		GB[4]	Bomb, MC-1, 750-lb		Dependent on type aircraft	1 bomb	50				11
							6 bombs	300	200	300	50	
							12 bombs	500	300	400	200	
							24 bombs	500	300	500	300	
			GB[4]	Spray tank, 100-gal			1 spray tank 2 spray tanks	RT max=750 meters (one-half effective spray release line length)				12
			VX[4]				1 spray tank	RT max=500 meters (one-half effective spray release line length)				16
			BZ[4]	Bomb, 150-lb Bomb, 700-lb								17

[1]RT max is largest target radius for which indicated casualty threat is tabulated for appropriate fire unit. Division of target into subtargets NOT considered.

[2]All windspeeds, temperature gradients, and protection categories considered.

[3]RT max computed for maximum number of volleys for which data are tabulated.

[4]Weapon system capabilities derived from tables composed of hypothetical data for INSTRUCTIONAL PURPOSES ONLY at the U. S. Army Command and General Staff College. For actual data, refer to FM 3-10.

Table 2. Estimated Fractional Casualty Threat From 105-mm Howitzer, GB Projectile, Battery Fire[1 2]

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Target radius–radius of effect (meters)	Range to target (km)	No of volleys	Windspeed[3]											
			4 kmph				9 kmph				28 kmph			
			Surprise[4]	Total dose[5]			Surprise[4]	Total dose[5]			Surprise[4]	Total dose[5]		
				I	N	L		I	N	L		I	N	L
50	<7.5	1	.10	.25	.20	.15	.10	.15	.10	.10				
		2	.20	.45	.40	.30	.15	.30	.25	.20		.10	.05	.05
		3	.30	.60	.60	.35	.30	.50	.45	.30	.10	.20	.15	.10
		4	.30	.75	.70	.45	.30	.55	.45	.35	.10	.25	.20	.10
		5	.35	.90	.85	.55	.35	.60	.50	.40	.15	.30	.25	.15
	>7.5	1	.05	.15	.15	.10	.05	.10	.05	.05				
		2	.15	.30	.25	.15	.10	.20	.15	.10		.05	.05	
		3	.15	.30	.30	.25	.10	.20	.20	.15		.10	.05	.05
		4	.20	.40	.35	.25	.15	.30	.30	.15	.05	.15	.15	.05
		5	.25	.45	.45	.30	.25	.40	.35	.25	.10	.20	.20	.10
100	<7.5	1	.05	.15	.15	.10	.05	.10	.05	.05				
		2	.10	.30	.30	.15	.10	.20	.15	.10				
		3	.15	.40	.35	.20	.15	.25	.25	.15	.05	.10	.05	
		4	.15	.40	.35	.30	.15	.30	.30	.15	.05	.10	.10	.05
		5	.20	.45	.40	.35	.20	.35	.35	.20	.10	.15	.15	.10
	≥7.5	1	.05	.10	.10	.05		.05	.05					
		2	.10	.20	.20	.10	.05	.15	.10	.05				
		3	.10	.25	.25	.15	.10	.15	.15	.10		.05	.05	
		4	.10	.30	.25	.20	.10	.25	.20	.15		.10	.05	
		5	.15	.35	.30	.25	.15	.30	.25	.15	.05	.15	.10	.05
200	Any	1		.05	.05									
		2		.10	.10	.05		.05	.05					
		3	.05	.15	.15	.05		.10	.05					
		4	.05	.15	.15	.10		.10	.10					
		5	.05	.20	.20	.10	.05	.15	.10	.05				

[1]Blank spaces indicate fractional casualties are below 0.05.

[2]If the target is predominately wooded, use a windspeed of 4 kmph and neutral temperature gradient for total dose attack; use a windspeed of 4 kmph for surprise attack.

[3]For windspeeds other than those shown, use data given for the nearest windspeed.

[4]Multiply the figures given in the table by the appropriate factor to obtain the fractional casualties from surprise dose attack:

Troops in open foxholes:	0.7
Troops in covered foxholes or bunkers:	0.6

[5]I=inversion, N=neutral, L=lapse.

Table 17. BZ Munitions Requirements

1	2	3	4	5	6
Munition	Casualty level[2]	Area coverage[1] (square kilometers)			
		Windspeed[3]			
		8 kmph		16 kmph	
		Temperature gradient		Temperature gradient	
		Inversion	Neutral	Inversion	Neutral
150-lb bomb	.40	.05	.02	.03	.01
	.75	.03	.01	.02	.009
700-lb bomb	.40	.20	.07	.09	.04
	.75	.10	.04	.05	.03

[1]Area coverages are for one bomb.

[2]Casualty levels are for personnel without masks available. For personnel with masks available, multiply casualty levels by 0.7.

[3]For windspeeds other than those shown, use data given for the nearest windspeed.

NOTE: The above table is composed of hypothetical munitions and data for INSTRUCTIONAL PURPOSES ONLY at the U. S. Army Command and General Staff College. For actual data, refer to FM 3-10.

Table 18. HD Ammunition Expenditure for Vapor Effect (50 Percent Coverage of Target Area)[1] [2]

Rounds required per hectare — 4.2-inch mortar (cartridge M2A1)

Desired effect[3]	Exposure time (hours), Temperature (°F) 55°	70°	85°	100°	Windspeed (kmph) 6, Temperature gradient[4] I	6 N	6 L	9 I	9 N	9 L	15 I	15 N	15 L	26 I	26 N	26 L
Cause eye irritation to troops without masks.	1	½	¼	⅛	10	14	16	11	21	22	15	22	26	20	24	29
	2	1	½	¼	6	8	9	8	12	14	12	13	16	17	21	24
	4	2	1	½	6	6	8	8	9	10	9	10	13	13	16	20
	8	4	2	1	4	6	6	6	8	9	8	9	11	12	13	15
	16	8	4	2	4	5	5	5	8	9	8	8	10	10	11	13
Disable masked troops (sweating in humid weather).	1	½	¼	⅛	35	46	52	39	53	63	46	63	80	59	77	108
	2	1	½	¼	20	29	33	24	35	40	30	45	56	41	59	69
	4	2	1	½	15	21	24	17	27	33	24	35	42	30	47	65
	8	4	2	1	11	17	18	13	21	26	17	28	38	27	45	63
	16	8	4	2	9	14	16	11	18	22	16	24	33	24	42	58
Disable masked troops (dry weather).	1	½	¼	⅛	64	83	95	72	95	114	86	113	144	108	144	198
	2	1	½	¼	36	52	58	44	62	72	57	81	101	71	120	125
	4	2	1	½	26	35	41	30	46	56	45	62	76	57	86	119
	8	4	2	1	18	27	30	23	35	44	32	50	68	50	81	114
	16	8	4	2	13	21	26	18	30	40	29	46	60	42	72	108

Rounds required per hectare — 105-mm howitzer (cartridge M60)

Desired effect[3]	Exposure time (hours), Temperature (°F) 55°	70°	85°	100°	Windspeed (kmph) 6, Temperature gradient[4] I	6 N	6 L	9 I	9 N	9 L	15 I	15 N	15 L	26 I	26 N	26 L
Cause eye irritation to troops without masks.	1	½	¼	⅛	22	24	27	24	34	39	39	44	46	32	53	65
	2	1	½	¼	18	22	23	20	22	27	29	32	34	26	39	51
	4	2	1	½	16	17	20	17	18	20	20	22	24	22	29	39
	8	4	2	1	12	15	17	13	12	17	15	20	22	18	27	36
	16	8	4	2	10	12	13	10	11	15	12	17	20	15	24	34
Disable masked troops (sweating in humid weather).	1	½	¼	⅛	70	83	108	77	95	121	95	123	166	108	157	243
	2	1	½	¼	42	54	63	47	63	84	66	89	102	82	108	192
	4	2	1	½	27	36	45	32	47	62	48	64	84	64	88	162
	8	4	2	1	18	29	34	24	38	47	33	53	76	54	83	138
	16	8	4	2	15	23	27	18	32	42	30	51	66	48	72	120
Disable masked troops (dry weather).	1	½	¼	⅛	128	154	174	144	174	212	189	...	...	202	...	...
	2	1	½	¼	75	98	128	89	113	147	111	156	180	148	198	288
	4	2	1	½	50	64	81	59	86	111	88	118	153	117	165	256
	8	4	2	1	33	50	58	45	65	84	62	95	138	101	154	240
	16	8	4	2	26	39	45	34	56	72	54	84	120	84	132	193

Rounds required per hectare — 155-mm howitzer and gun (projectiles M110 and M104)

Desired effect[3]	Exposure time (hours), Temperature (°F) 55°	70°	85°	100°	Windspeed (kmph) 6, Temperature gradient[4] I	6 N	6 L	9 I	9 N	9 L	15 I	15 N	15 L	26 I	26 N	26 L
Cause eye irritation to troops without masks.	1	½	¼	⅛	8	10	10	9	11	12	10	12	13	11	14	16
	2	1	½	¼	6	8	9	8	10	11	9	11	12	10	12	14
	4	2	1	½	4	5	6	6	8	9	8	9	10	9	10	12
	8	4	2	1	4	5	5	5	6	8	6	8	9	8	9	11
	16	8	4	2	4	4	4	4	5	6	5	6	8	5	8	10
Disable masked troops (sweating in humid weather).	1	½	¼	⅛	20	28	30	23	32	36	26	39	44	32	46	58
	2	1	½	¼	12	17	20	15	22	24	18	27	34	24	36	46
	4	2	1	½	10	13	16	11	18	20	15	20	27	18	29	33
	8	4	2	1	6	10	12	9	13	16	12	17	24	16	23	33
	16	8	4	2	5	9	11	8	11	15	11	15	22	15	20	29
Disable masked troops (dry weather).	1	½	¼	⅛	36	48	53	41	56	63	46	66	78	59	83	105
	2	1	½	¼	21	28	33	26	36	41	38	54	63	42	65	84
	4	2	1	½	15	21	26	18	28	33	26	36	45	33	50	66
	8	4	2	1	11	16	18	13	21	26	22	33	40	28	42	56
	16	8	4	2	9	12	15	11	18	21	18	30	36	24	38	46

[1] For open terrain. For heavily wooded terrain or jungle, multiply the figure obtained by 0.5 to obtain the appropriate expenditure.

[2] Blank spaces indicate excessive expenditures.

[3] An average of 50 percent casualties is expected among all troops who remain in the target area for the times specified.

[4] I = inversion, N=neutral, L=lapse.

Field Manual
No 3-6

Air Force Manual
No 105-7

Fleet Marine Force Manual
No. 7-11-H

HEADQUARTERS
DEPARTMENT OF THE ARMY
DEPARTMENT OF THE AIR FORCE
UNITED STATES MARINE CORPS
Washington, DC, 3 November 1986

FIELD BEHAVIOR OF NBC AGENTS
(INCLUDING SMOKE AND INCENDIARIES)

Table of Contents

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DISPERSION CATEGORY	ATMOSPHERIC DESCRIPTION	TRADITIONAL ATMOSPHERIC CONDITIONS
1	Very Unstable	Lapse
2	Unstable	Lapse
3	Slightly Unstable	Neutral
4	Neutral	Neutral
5	Slightly Stable	Neutral
6	Stable	Inversion
7	Extremely Stable	Inversion

Figure 1-1. Atmospheric stability categories and conditions.

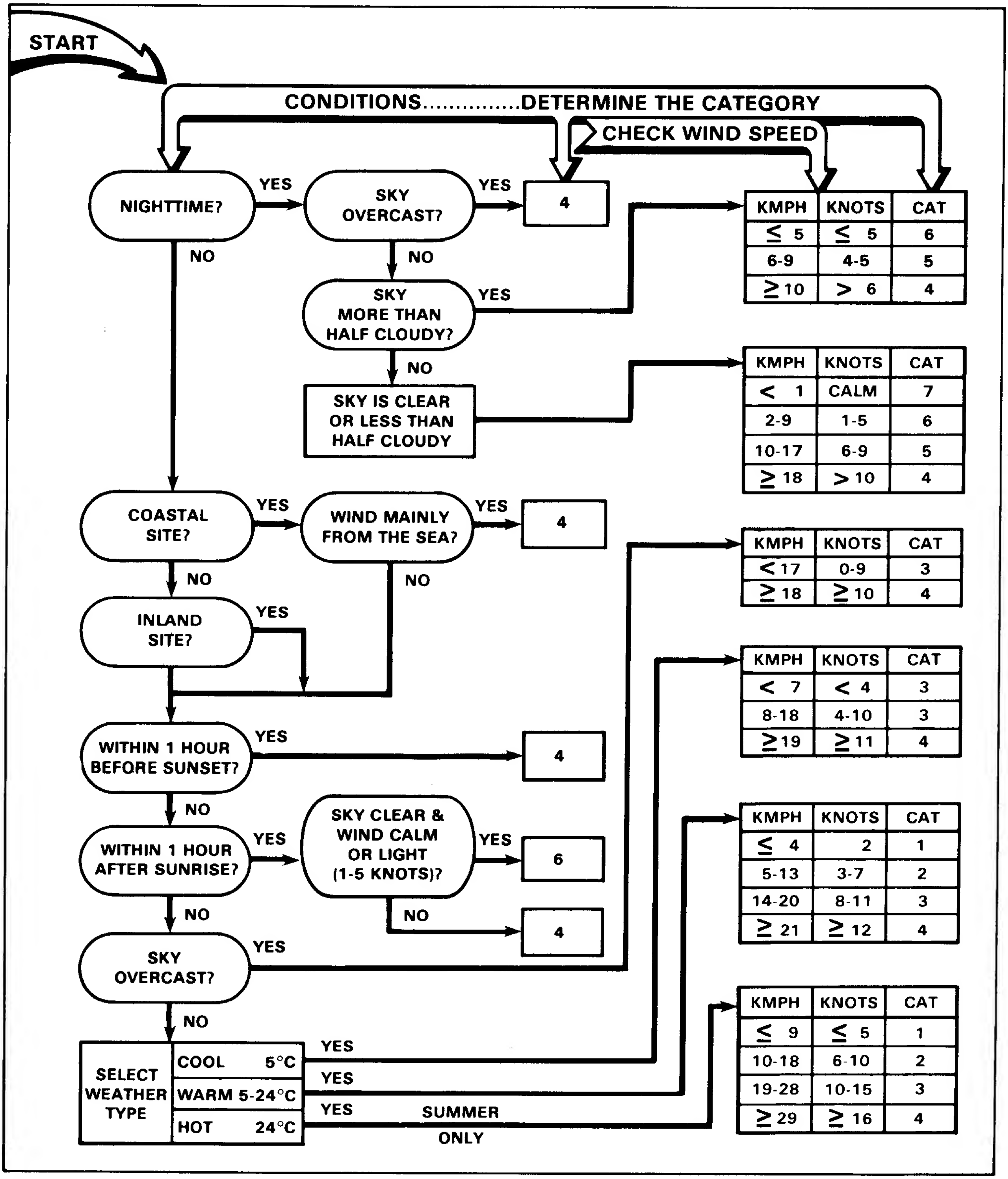


Figure 1-2. Stability decision tree.

Page 1-14 states that the mixed air layer height is 50-100 m on a clear, calm night, just before 400 m before sunrise, and 2 km on a hot summer day

Table 1-3. Center line dosages at different distances downwind for different dispersion categories and wind speeds for a unit source. 100 kilograms of GB

STABILITY CATEGORY	Wind Speed	DOWNWIND DISTANCE IN KM							
		.5	1	2	4	6	10	20	30
		DOSAGES (mg-min/M^3)							
1	1	57.82	10.960	2.4820	1.2070	.8048	.48290	.24140	.16100
	3	19.15	3.628	.8224	.3998	.2665	.15990	.07995	.05330
	5	11.47	2.174	.4928	.2396	.1597	.09582	.04791	.03194
2	3	65.93	16.480	4.121	1.0300	.4671	.22840	.11360	.07575
	6	32.86	8.215	2.054	.5135	.2328	.11380	.05663	.03775
	10	19.75	4.938	1.235	.3087	.1400	.06843	.03404	.02269
3	3	172.60	46.26	12.400	3.321	1.5370	.5825	.18010	.11510
	7	73.86	19.79	5.302	1.421	.6576	.2492	.07703	.04925
	12	43.09	11.55	3.094	.829	.3837	.1454	.04494	.02874
4	3	572.4	170.20	50.590	15.040	7.398	3.0260	.8997	.44450
	8	213.9	63.61	18.910	5.622	2.765	1.1310	.3363	.16620
	16	107.1	31.84	9.467	2.814	1.384	.5662	.1683	.08318
5	2	1,837.0	606.0	199.90	65.94	34.470	15.220	5.021	2.6250
	5	736.2	242.9	80.12	26.43	13.810	6.101	2.012	1.0520
	9	408.7	134.8	44.47	14.67	7.668	3.387	1.117	.5839
6	1	10,080.0	3,691.0	1,351.0	494.50	274.70	131.00	47.930	26.630
	3	3,339.0	1,222.0	447.4	163.80	90.96	43.37	15.870	8.818
	5	2,001.0	732.4	268.1	98.12	54.51	25.99	9.5120	5.284
7	HIGHER DOSAGES THAN ABOVE								

Table 1-4. Summary of favorable and unfavorable weather and terrain conditions for tactical employment of chemical agent vapor or aerosol. (The stability condition listed for the south slope is for the northern hemisphere; due to solar loading on the slope, the situation would be reversed for the southern hemisphere.)

FACTOR	UNFAVORABLE	MODERATELY FAVORABLE	FAVORABLE
Wind	Artillery employment if speed is more than 7 knots. Aerial bombs if speed is more than 10 knots.	Steady, 5 to 7 knots, or land breeze.	Steady, less than 5 knots, or sea breeze.
Dispersion Category	Unstable (lapse).	Neutral.	(Stable) inversion.
Temperature	Less than 4.4°C.	4.4° to 21.1°C.	More than 21.1°C.
Precipitation	Any.	Transitional.	None.
Cloud Cover	Broken, low clouds during daytime. Broken, middle clouds during daytime. Overcast or broken, high clouds during daytime. Scattered clouds of all types during daytime. Clouds of vertical development.	Thick, low overcast. Thick, middle overcast.	Broken, low clouds at night. Broken, middle clouds at night. Overcast or broken, high clouds at night. Scattered clouds of all types at night. Clear sky at night.
Terrain	Hilltops, mountain crests. South slopes* during daytime.	Gently rolling terrain. North slopes at night.	Even terrain or open water.
Vegetation*	Heavily wooded or jungle.	Medium dense.	Sparse or none.

*Cloud dissemination occurs above the canopy.

Chemical and biological contamination avoidance, FM 3-3 (1992)

10 grams/square meter

TABLE 1-2. Chemical Agent Persistency in Hours on CARC Painted Surfaces.

Temperature		GA/GF[1]	GB[2,3]	GD[2,3]	HD[1]	VX[2,3]
C°	F°					
-30	-22	*	110.34	436.69	**	***
-20	-4	*	45.26	145.63	**	***
-10	14	*	20.09	54.11	**	***
0	32	*	9.44	22.07	**	***
10	50	1.42	4.70	9.78	12	1776
20	68	0.71	2.45	4.64	6.33	634
30	86	0.33	1.35	2.36	2.8	241
40	104	0.25	0.76	1.25	2	102
50	122	0.25	0.44	0.70	1	44
55	131	0.25	0.34	0.51	1	25

NOTE
1 For grassy terrain multiply the number in the chart by 0.4.
2 For grassy terrain multiply the number in the chart by 1.75.
3 For sandy terrain multiply the number in the chart by 4.5.
* Agent persistency time is less than 1 hour.
** Agent is in a frozen state and will not evaporate or decay.
*** Agent persistency time exceeds 2,000 hours.

REFERENCE BOOK
3—2*

U.S. ARMY COMMAND AND GENERAL STAFF COLLEGE
Fort Leavenworth, Kansas, *25 July 1983*

CHEMICAL WEAPONS EMPLOYMENT DATA

Page

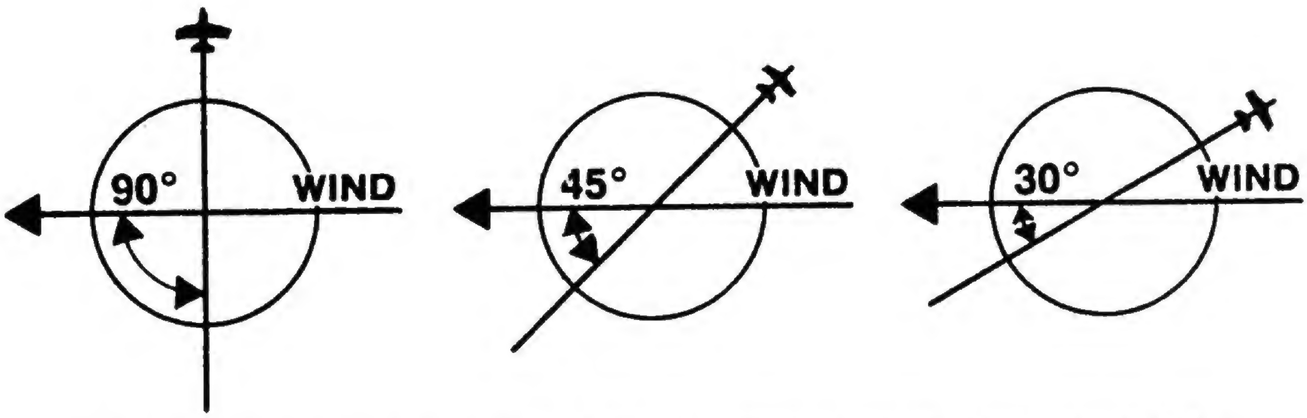
*This reference book replaces RB 3—2, 8 July 1981, for all resident and nonresident programs.

Section X
Spray Tank/VX

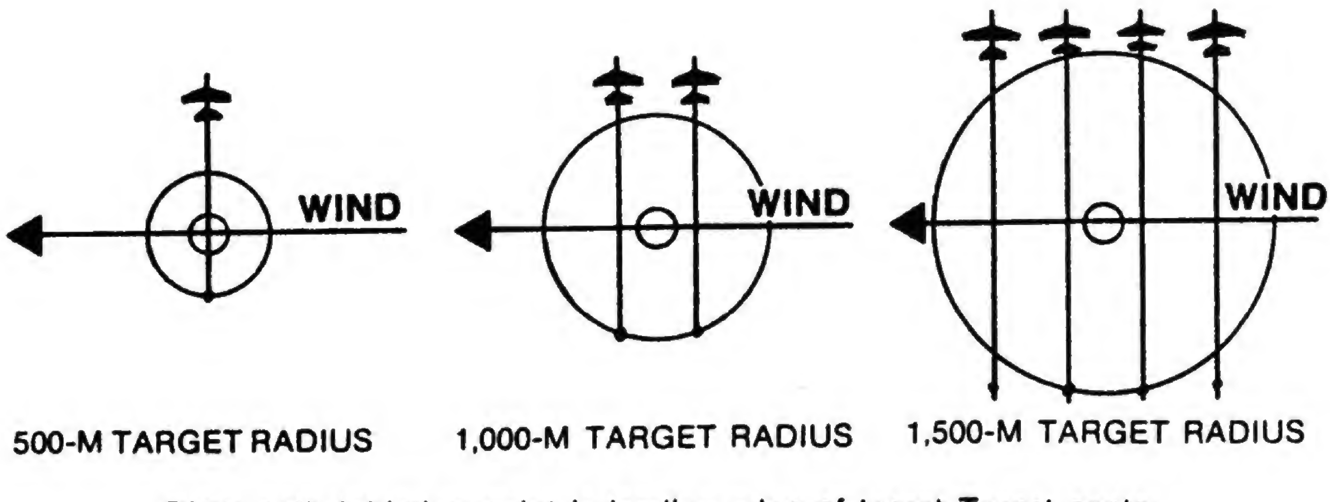
AIM POINT & FLIGHT PATH ADJUSTMENTS
VARIABLE DELIVERY TECHNIQUES

DELIVERY SYSTEM	**TANKS/AIRCRAFT**	**AIRCRAFT SPEED***
Refer to Air Force & Navy Publications	Minimum 1 Maximum 2	450 Knots Centered Delivery

$$\textbf{Altitude of Spray Release Line} = \frac{\textbf{Windspeed - Height Product (VWH)}}{\textbf{Windspeed in Knots}}$$



FLIGHT PATH IN RELATION TO WIND DIRECTION



Flight path Initiation point is leading edge of target Target center

**Used on all tables in this section.*

Table I-79. Spray Tank/VX Aim Point & Flight Path Adjustments

Spray Tank/VX

Expected Fraction of Casualties

PROTECTION CATEGORY: A (NO MASK OR PROTECTIVE CLOTHING)
CASUALTIES WITHIN: 1/2 HOUR

FLOW RATE	WIND ANGLE	TARGET RADIUS (Meters)	WINDSPEED-HEIGHT PRODUCT (VWH)															
			500 NO. AIRCRAFT			750 NO. AIRCRAFT			1000 NO. AIRCRAFT			2000 NO. AIRCRAFT			3000 NO. AIRCRAFT			
			1	2	4	1	2	4	1	2	4	1	2	4	1	2	4	
ONE TANK AT HALF FLOW	90°	500	.08	.15	.20	.17	.37	.60	.25	.46	.68	.25	.43	.60	.19	.35	.50	
		1000	.01	.04	.10	.06	.15	.31	.09	.19	.45	.09	.20	.45	.09	.20	.45	
		1500	—	.02	.07	—	.06	.14	—	.06	.19	—	.06	.22	—	.08	.23	
	45°	500	.04	.11	.23	.13	.29	.61	.20	.41	.69	.22	.41	.64	.21	.37	.57	
		1000	.01	.04	.11	.04	.10	.23	.07	.16	.36	.08	.19	.42	.08	.19	.42	
		1500	—	—	.07	—	.06	.12	—	.08	.18	—	.08	.20	—	.08	.22	
	30°	500	.02	.07	.16	.10	.23	.48	.15	.32	.64	.17	.36	.62	.18	.35	.57	
		1000	—	.03	.08	.03	.09	.20	.06	.13	.29	.07	.15	.34	.07	.16	.36	
		1500	—	—	.04	—	.04	.09	—	.06	.14	—	.08	.18	—	.08	.20	
TWO TANKS AT HALF FLOW	90°	500	.08	.17	.30	.22	.46	.69	.34	.55	.69	.31	.50	.65	.25	.43	.60	
		1000	.01	.05	.11	.10	.19	.41	.13	.29	.61	.15	.33	.53	.18	.35	.51	
		1500	.01	.03	.10	.05	.11	.25	.07	.17	.38	.09	.20	.46	.09	.22	.49	
	45°	500	.06	.13	.28	.18	.37	.71	.27	.50	.71	.30	.50	.67	.29	.47	.62	
		1000	.02	.06	.13	.06	.14	.31	.11	.24	.51	.13	.29	.60	.15	.32	.63	
		1500	—	.02	.08	.03	.09	.20	.06	.14	.31	.07	.17	.38	.08	.19	.42	
	30°	500	.04	.09	.39	.13	.29	.73	.20	.41	.69	.23	.44	.63	.24	.43	.57	
		1000	.01	.04	.10	.05	.11	.26	.09	.19	.41	.10	.23	.51	.12	.26	.56	
		1500	—	.01	.06	.02	.07	.14	.04	.11	.24	.06	.13	.29	.07	.15	.34	

PROTECTION CATEGORY: A (NO MASK OR PROTECTIVE CLOTHING)
CASUALTIES WITHIN: 1 HOUR

FLOW RATE	WIND ANGLE	TARGET RADIUS (Meters)	WINDSPEED-HEIGHT PRODUCT (VWH)															
			500 NO. AIRCRAFT			750 NO. AIRCRAFT			1000 NO. AIRCRAFT			2000 NO. AIRCRAFT			3000 NO. AIRCRAFT			
			1	2	4	1	2	4	1	2	4	1	2	4	1	2	4	
ONE TANK AT HALF FLOW	90°	500	.08	.20	.27	.25	.50	.70	.36	.57	.69	.33	.53	.64	.28	.48	.58	
		1000	.02	.06	.15	.10	.22	.47	.16	.34	.65	.19	.39	.65	.22	.40	.63	
		1500	—	.04	.09	—	.10	.23	—	.12	.34	—	.15	.41	—	.21	.42	
	45°	500	.06	.14	.30	.19	.40	.71	.28	.52	.72	.31	.52	.68	.30	.49	.64	
		1000	.02	.06	.14	.07	.15	.33	.11	.25	.52	.14	.29	.55	.16	.32	.54	
		1500	—	.02	.07	—	.08	.19	—	.13	.34	—	.16	.38	—	.19	.43	
	30°	500	.04	.10	.22	.14	.30	.63	.21	.43	.69	.24	.45	.65	.25	.45	.59	
		1000	.01	.04	.10	.05	.12	.27	.09	.19	.41	.10	.23	.48	.12	25	.49	
		1500	—	.01	.05	—	.06	.14	—	.11	.24	—	.14	.31	—	.16	.37	
TWO TANKS AT HALF FLOW	90°	500	.11	.24	.41	.32	.57	.74	.39	.59	.72	.35	.55	.69	.29	.47	.66	
		1000	.03	.08	.19	.13	.28	.58	.21	.43	.72	.27	.49	.71	.31	.51	68	
		1500	.01	.05	.14	.07	.16	.37	.12	.26	.56	.16	.34	.66	.19	39	.67	
	45°	500	.08	.17	.37	.23	.48	.75	.35	.57	.72	.35	.55	.68	.32	.51	.65	
		1000	.03	.08	.17	.09	.20	.42	.16	.34	.67	.20	.42	.71	.24	.47	.71	
		1500	.01	.03	.10	.05	.13	.28	.09	.20	.44	.12	.26	.55	.14	.30	60	
	30°	500	.05	.13	.51	.17	.37	.74	.26	.50	.71	.28	.49	65	.28	.48	.64	
		1000	.02	.05	.13	.07	.16	.34	.12	.26	.55	.16	.33	.67	.18	38	.69	
		1500	—	.02	.07	.03	.10	.20	.07	.15	.35	.10	.19	.43	.10	23	.48	

Table I-80. Spray Tank/VX Expected Fraction of Casualties

PROTECTION CATEGORY: A (NO MASK OR PROTECTIVE CLOTHING)
CASUALTIES WITHIN: ULTIMATE

FLOW RATE	WIND ANGLE	TARGET RADIUS (Meters)	WINDSPEED-HEIGHT PRODUCT (VWH) 500 NO. AIRCRAFT 1	2	4	750 NO. AIRCRAFT 1	2	4	1000 NO. AIRCRAFT 1	2	4	2000 NO. AIRCRAFT 1	2	4	3000 NO. AIRCRAFT 1	2	4
ONE TANK AT HALF FLOW	90°	500	.14	.31	.43	.39	.62	.74	.39	.59	.69	.35	.55	.65	.30	.50	.60
		1000	.05	.12	.26	.18	.38	.69	.30	.54	.73	.35	.56	.70	.36	.56	.68
		1500	–	.06	.15	–	.21	.42	–	.31	.56	–	.34	.59	–	.41	.59
	45°	500	.10	.23	.49	.30	.56	.75	.39	.60	.72	.36	.56	.68	.33	.53	.65
		1000	.04	.10	.22	.12	.26	.53	.19	.39	.63	.23	.43	.61	.26	.44	.59
		1500	–	.06	.12	–	.16	.33	–	.27	.54	–	.35	.62	–	.41	.65
	30°	500	.07	.16	.36	.22	.45	.74	.30	.54	.69	.31	.52	.65	.30	.50	.60
		1000	.03	.07	.16	.09	.20	.42	.14	.29	.55	.16	.34	.56	.18	.35	.55
		1500	–	.04	.09	–	.12	.25	–	.20	.45	–	.27	.55	–	.33	.59
TWO TANKS AT HALF FLOW	90°	500	.18	.38	.64	.43	.64	.75	.39	.59	.73	.35	.55	.70	.30	.50	.67
		1000	.06	.15	.30	.21	.45	.74	.35	.59	.73	.39	.60	.71	.39	.59	.69
		1500	.04	.09	.22	.13	.28	.60	.22	.46	.72	.30	.54	.74	.34	.56	.72
	45°	500	.13	.28	.58	.35	.60	.75	.40	.61	.72	.36	.56	.68	.34	.53	.65
		1000	.05	.11	.27	.16	.33	.66	.27	.52	.75	.33	.57	.73	.37	.59	.72
		1500	.03	.06	.16	.10	.21	.44	.16	.34	.65	.21	.42	.69	.24	.46	.68
	30°	500	.09	.20	.72	.26	.51	.74	.33	.56	.74	.32	.53	.70	.31	.50	.67
		1000	.04	.09	.20	.12	.26	.54	.20	.41	.73	.25	.49	.74	.29	.53	.73
		1500	.02	.04	.12	.07	.16	.32	.12	.25	.52	.15	.30	.60	.17	.34	.61

Table I-81. Spray Tank/VX Expected Fraction of Casualties

Section XI
HD Munitions

HD DOSAGE REQUIREMENTS

HD DOSAGES mg/minute/cubic meter			PERSONNEL PROTECTION CATEGORY	CASUALTY EFFECTS	DEGREE OF DISABILITY	ONSET TIME	DURATION
HOT[1]	WARM[2]	COOL[3]					
50	50	50	"A" no mask or protective clothing	No significant injury; maximum safe dosage	--	--	--
100	100	100		Eye damage of threshold military significance	PARTIAL	6-24 HR	1-3 DAYS
200	200	200		Temporary blindness	TOTAL	3-12 HR	2-7 DAYS
100	150	400	"B" or "C" with no protective clothing	No significant injury; maximum safe dosage	--	--	--
200	300	1,000		Skin burns of threshold military significance	PARTIAL	2-12 DAYS	1-2 WEEKS
500	1,000	2,000 to 4000		Severe genital burns	PARTIAL TO TOTAL	2-7 DAYS	1-4 WEEKS
750	2,000 to 4,000	4,000 to 10,000		Severe generalized burns	PARTIAL TO TOTAL	4-12 HRS About 24 HRS	3-4 WEEKS 1-2 WEEKS
			"D" mask with protective clothing	HD IS NOT RECOMMENDED FOR USE IN THIS PROTECTION CATEGORY.			

[1]Hot, humid; above 80°F; sweating skin
[2]Warm: 60°-80°F; skin not wet with sweat
[3]Cool: 40°-60°F; cool, dry skin

Table I-85. HD Munitions

HD Contamination Replenishment Time (Rate Factors)

TERRAIN FACTOR **X** WINDSPEED FACTOR **X** GROUND SURFACE TEMPERATURE FACTOR **X** TEMPERATURE GRADIENT FACTOR[2] (STABILITY) **=** TIME (HOURS) FOR 50% EVAPORATION OF HD

FACTORS

TERRAIN	WINDSPEED[1] (knots)	GROUND SURFACE TEMPERATURE (°F)	TEMPERATURE GRADIENT[2]
	1 = 3.1		
OPEN GRASSLAND = 1	2 = 1.8		INVERSION = 1.2
	3 = 1.3		
	4 = 1.0	50° = 4.0	
		60° = 2.5	
FOREST OR JUNGLE 1	5 = 0.8	70° = 1.6	NEUTRAL = 1.0
	6 = 0.7	80° = 1.0	
	7 = 0.6	90° = 0.6	
	9 = 0.5	100° = 0.4	
	11 = 0.4	110° = 0.3	
		120° = 0.2	
BARREN SOIL OR SAND = 2	14 = 0.3		LAPSE = 0.7
	18 = 0.3		

[1]at 2 meters high in the open
[2]in the open

Table I-96. HD Contamination Replenishment Time (Rate Factors)

Approximate Duration of Hazard in Contaminated Terrain

TASK	TERRAIN	APPROXIMATE TIME AFTER CONTAMINATION THAT PRESCRIBED TASKS MAY BE PERFORMED WITH NEGLIGIBLE RISK[1] (Not wearing protective clothing)[2]			
		BLISTER AGENT (HD) TEMPERATURE[3]		NERVE AGENT (VX-GB) UNIFORM[4]	
		WARM (70°-85°F)	HOT (80°-100°F)	SUMMER	WINTER
		WEARING MASKS			
TRAVERSAL[5] (Walking across area 2 hours or less	Bare soil or low vegetation[6] (except sand)	36 HOURS	36 HOURS	5 HOURS	2 HOURS
	High vegetation, including jungle and heavy woods	4 DAYS	2 DAYS	28 HOURS	10 HOURS
		NOT WEARING MASKS[7]			
OCCUPATION (Without hitting ground 24 hours)	Bare soil or low vegetation[6] (except sand)	4 DAYS	3 DAYS	32 DAYS	13 DAYS
	High vegetation, including jungle and heavy woods	4 DAYS	3 DAYS	32 DAYS	13 DAYS
OCCUPATION (Involving advance under fire 24 hours)	Bare soil or low vegetation[6] (except sand)	4 DAYS	3 DAYS	32 DAYS	13 DAYS
	High vegetation including jungle and heavy woods	6 DAYS	4 DAYS	50 DAYS	18 DAYS

[1]These times are safe-sided for troop safety.
[2]Leather combat boots treated with protective dubbing or rubber combat boots are worn.
[3]Effects of blister agent vary significantly with temperature. Mustard freezes in temperatures below 60°F and can present a hazard when the temperature rises.
[4]Protection from V-agent and thickened G-agent varies significantly with layers of clothing worn.
[5]For personnel walking for 2 hours in an area contaminated by blister agents, the limiting factor is the vapor hazard. If only a few minutes are required for traversal of the area, the task can be initiated at earlier times than those given.
[6]Times shown are not applicable to sand, which will hold chemical agents for longer periods of time than those given.
[7]The data refer to approximate times at which personnel could occupy contaminated areas without having to wear protective masks for protection against vapor hazard.

Table I-97. Approximate Duration of Hazard in Contaminated Terrain

WARNING
This table is intended as a guide only.
Chemical agent detectors must be used to determine the extent of actual contamination and vapor hazards.

Table 5-2. Potential Biological Warfare Agents.

Microorganism	Mode of Transmission	Incubation Period (Days)[2]	Mortality Rate (Percent)2	Vaccine ([3])	Treatment ([4])
Bacteria					
Bacillus Anthracis (Anthrax)	A, D[9], I	1-7	5-1005	+	E[6]
Francisella Tularensis (Tularemia)	A, D[9], I, V	1-10	<30	+ +	E
Yersinia Pestis (Plague)	A, V	2-6	25-1007	+ + +	E[6]
Vibrio Cholerae (Cholera)	I	1-5	15-90	+ + +	E
Corynebacterium Diptheriae (Diptheria)	A, D[9]	2-5	5-12	+ + +	E
Salmonella Typhi (Typhoid Fever)	I	6-21	7-14	+ + +	E
Rickettsiae					
Rickettsia SPP (Spotted fevers group)	V	6-15	10-40	+ + +	E
Rickettsiae (Endemic or flea-borne typhus)	V	6-14	2-5	N	E
Rickettsia (Rocky Mountain spotted fever)	V	3-10	30 (approx)	N	E
Coxiella Burnetii (Q fever)	A, I	14-21	<1	+ +	E

[1] Transmission can be by aerosol-A, direct contact-D, ingestion-I, and/or vector-V.
[2] Incubation periods and mortality rates vary according to a number of factors (such as ability of the host to resist infection, infective dose, portal of entry, and virulence of the microorganism).
[3] + indicates vaccine available but of questionable value; + + indicates vaccine available, but mainly used in high risk individuals; + + + indicates vaccine used extensively; N indicates no vaccine available.
[4] E indicates effective treatment available; N indicates no specific treatment.
[5] The mortality rate is lower when the agent enters through the skin; higher when it enters through the respiratory tract.
[6] Treatment must be initiated in the earliest stage of the pulmonary form to be effective.
[7] The 25 percent represents mortality due to bubonic form; 100 percent represents mortality due to pneumonic form.
[8] Mosquitoes are thought to be the primary vectors, but this has not been proven.
[9] Direct contact refers to being bitten by a rabid animal, which is the usual means of transmission, or coming into contact with a rabid animal.

Table 5-2. Potential Biological Warfare Agents (continued).

Microorganism	Mode of Transmission	Incubation Period (Days)[2]	Mortality Rate (Percent)2	Vaccine ([3])	Treatment ([4])
Viruses					
Eastern Equine Encephalitis (EEE)	V[8]	4-24	60 (Approx)	N	N
Venezuelan Equine Encephalitis (VEE)	V[8]	4-24	<1	+ +	N
Japanese B Encephalitis	V (Mosquito)	5-15	10-80	+ +	N
Russian SpringùSummer Encephalitis (RSSE)	V (Tick)	7-14	3-40	+	N
Yellow Fever	V (Mosquito)	3-6	5-40	+ + +	N
Dengue Fever	V (Mosquito)	4-10	<1	+	N
Pox Virus					
Variloa Virus (Smallpox)	A, D[9]	7-16	10-25	+ + +	N
Hantaan Virus (Hemorrhagic Fever with Renal Syndrome)	A, V				
Phlebovirus (Rift Valley Fever)	V (Mosquito)	4-6	<1	N	N
Nairovirus (Crimean-Congo Hemorrnagil Fever)	V (Tick)	3-7			
Bunyavirus (LA Crosse)	V (Mosquito)				
Phlebovirus(Sandfly)	V (Sand fly)	3-6			

[1] Transmission can be by aerosol-A, direct contact-D, ingestion-I, and/or vector-V.
[2] Incubation periods and mortality rates vary according to a number of factors (such as ability of the host to resist infection, infective dose, portal of entry, and virulence of the microorganism).
[3] + indicates vaccine available but of questionable value; + + indicates vaccine available, but mainly used in high risk individuals; + + + indicates vaccine used extensively; N indicates no vaccine available.
[4] E indicates effective treatment available; N indicates no specific treatment.
[5] The mortality rate is lower when the agent enters through the skin; higher when it enters through the respiratory tract.
[6] Treatment must be initiated in the earliest stage of the pulmonary form to be effective.
[7] The 25 percent represents mortality due to bubonic form; 100 percent represents mortality due to pneumonic form.
[8] Mosquitoes are thought to be the primary vectors, but this has not been proven.
[9] Direct contact refers to being bitten by a rabid animal, which is the usual means of transmission, or coming into contact with a rabid animal.

Table 5-3. Threat Toxins.

Type of Toxin	Means of ID	Symptoms in Man	Effects on Man	Rate of Action	How Normally Disseminated	Protection Required	Decontamination
Mycotoxins	None	Vomiting, eye and skin irritation, dizziness, bloody diarrhea, and blisters.	Can incapacitate or kill, depending on concentration.	Rapid	Dusts, droplets, aerosols, smokes, or covert means	Protective mask and protective clothing	Soap and water, bleach, M258-series kit, STB and DS2
Enterotoxins	None	Severe vomiting and diarrhea, painful cramps, and weakness	Primarily incapacitates, assuming proper first aid is conducted	Same as above	Same as above	Same as above	Same as above
Botulinum Toxin	None	Double vision, weakness, difficulty in speech and swallowing, and respiratory paralysis	Kills	Delayed	Same as above	Same as above	Same as above

POTENTIAL MILITARY CHEMICAL/BIOLOGICAL AGENTS AND COMPOUNDS, US Army FM 3-11.9, 2005

Table G-4. Toxicity Estimates for CW Agents

ROE		Liquid (mg/70 kg man)		Inhalation/Ocular (mg-min/m³)			Inhalation (mg/m³)	Ocular (mg-min/m³)		Percutaneous Vapor (mg-min/m³)			
Endpoints		Lethal (LD_{50})	Severe (ED_{50})	Lethal (LCt_{50})	Severe (ECt_{50})	Mild (ECt_{50})	Odor Detection (EC_{50})	Severe (ECt_{50})	Mild (ECt_{50})	Lethal (LCt_{50}) Moderate	Lethal (LCt_{50}) Hot	Severe (ECt_{50}) Moderate	Severe (ECt_{50}) Hot
Choking Agents	CG	-	-	1,500 (2-60)	-	-	6 S	-	-	-	-	-	-
	DP	-	-	1,500P (10-60)	-	-	4 S	-	-	-	-	-	-
Nerve Agents	GA	1,500	900	70 (2)	50 (2)	0.4 (2)	-	-	-	15,000 (30-360)	7,500P (30-360)	12,000 (30-360)	6,000P (30-360)
	GB	1,700	1,000	35 (2)	25 (2)	0.4 (2)	-	-	-	12,000 (30-360)	6,000P (30-360)	8,000 (30-360)	4,000P (30-360)
	GD	350	200	35 (2)	25 (2)	0.2 (2)	-	-	-	3,000 (30-360)	1,500P (30-360)	2,000 (30-360)	1,000P (30-360)
	GF	350	200	35 (2)	25 (2)	0.2 (2)	-	-	-	3,000 (30-360)	1,500P (30-360)	2,000 (30-360)	1,000P (30-360)
	VX	5	2	15 (2-360)	10 (2-360)	0.1 (2-360)	-	-	-	150 (30-360)	75P (30-360)	25 (30-360)	12P (30-360)
	Vx	NR											
Blood Agent	AC	-	-	2860P (2)	NR		34 S	-	-	-	-	-	-
	CK	-	-	NR	NR		12 S	-	-	-	-	-	-
	SA	-	-	7,500P (2)	-	-	-	-	-	-	-	-	-
Blister Agents	HD	1400	600	1,000 (2)	-	-	0.6 – 1 S	75 (2-360)	25 (2-360)	10,000 (30-360)	5,000P (30-360)	500 (30-360)	200 (30-360)
	HN-1	1400P	600P	1,000P (2)	-	-	-	75P (2)	25P (2)	10,000P (30)	5,000P (30)	500P (30)	200P (30)
	HN-2	1400P	600P	1,000P (2)	-	-	-	75P (2)	25P (2)	10,000P (30)	5,000P (30)	500P (30-360)	200P (30-360)
	HN-3	1400P	600P	1,000P (2-360)	-	-	-	75P (2-360)	25P (2-360)	10,000P (30-360)	5,000P (30-360)	500P (30-360)	200P (30-360)
	HT	1400P	600P	1,000P (2-360)	-	-	-	75P (2-360)	25P (2-360)	10,000P (30-360)	5,000P (30-360)	500P (30-360)	200P (30-360)
	L	1400P	600P	1,000P (2-360)	-	-	8 S	75P (2-360)	25P (2-360)	5,000 - 10,000P (30-360)	2,500 - 5,000P (30-360)	500P (30-360)	200P (30-360)
	HL	1400P	600P	1,000P (2-360)	-	-	2 S	75P (2-360)	25P (2-360)	10,000P (30-360)	5,000P (30-360)	500P (30-360)	200P (30-360)

COMPARATIVE VOLATILITY OF CHEMICAL WARFARE AGENTS

Agent	Volatility (mg/m^3) at 25°C
Hydrogen cyanide (HCN)	1,000,000
Sarin (GB)	22,000
Soman (GD)	3,900
Sulfur mustard	900
Tabun (GA)	610
Cyclosarin (GF)	580
VX	10
VR ("Russian VX")	9

Data source: US Departments of the Army, Navy, and Air Force. *Potential Military Chemical/Biological Agents and Compounds*. Washington, DC: Headquarters, DA, DN, DAF; December 12, 1990. Field Manual 3-9. Naval Facility Command P-467. Air Force Regulation 355-7.

SIGNS AND SYMPTOMS REPORTED BY TOKYO HOSPITAL WORKERS TREATING VICTIMS OF SARIN SUBWAY ATTACKS*

Symptom	Number/percentage of the 15 physicians who treated patients at UH		Number/percentage of 472 care providers reporting symptoms at SLI	
Dim vision	11	73%	66	14%
Rhinorrhea	8	53%	No information	
Dyspnea (chest tightness)	4	27%	25	5.3%
Cough	2	13%	No information	
Headache	No information		52	11%
Throat pain	No information		39	8.3%
Nausea	No information		14	3.0%
Dizziness	No information		12	2.5%
Nose pain	No information		6	1.9%

*Data reflect reported survey of self-reported symptomatology of physicians at the University Hospital of Metropolitan Japan emergency department and all hospital workers at Saint Luke's International Hospital exposed to sarin vapors from victims of the Tokyo subway attack.

SLI: Saint Luke's International Hospital

UH: University Hospital

Data sources: (1) Nozaki H, Hori S, Shinozawa Y, et al. Secondary exposure of medical staff to sarin vapor in the emergency room. *Intensive Care Med*. 1995;21:1032-1035. (2) Okumura T, Suzuki K, Fukuda A, et al. The Tokyo subway sarin attack: disaster management, Part 1: community emergency response. *Acad Emerg Med*. 1998;5:613-617. (3) Okumura T, Suzuki K, Fukuda A, et al. The Tokyo subway sarin attack: disaster management, Part 2: Hospital response. *Acad Emerg Med*. 1998;5:618-624.

TABLE 21-3

MANAGEMENT OF MILD TO MODERATE NERVE AGENT EXPOSURES

		Management			
		Antidotes*		Benzodiazepines (if neurological signs)	
Nerve Agents	Symptoms	Age	Dose	Age	Dose
• Tabun • Sarin • Cyclosarin • Soman • VX	• Localized sweating • Muscle fasciculations • Nausea • Vomiting • Weakness/floppiness • Dyspnea • Constricted pupils and blurred vision • Rhinorrhea • Excessive tears • Excessive salivation • Chest tightness • Stomach cramps • Tachycardia or bradycardia	Neonates and infants up to 6 months old	**Atropine** 0.05 mg/kg IM/IV/IO to max 4 mg or 0.25 mg AtroPen† and **2-PAM** 15 mg/kg IM or IV slowly to max 2 g/hr	Neonates	**Diazepam** 0.1–0.3 mg/kg/dose IV to a max dose of 2 mg, or **Lorazepam** 0.05 mg/kg slow IV
		Young children (6 months old–4 yrs old)	**Atropine** 0.05 mg/kg IM/IV/IO to max 4 mg or 0.5 mg AtroPen and **2-PAM** 25 mg/kg IM or IV slowly to max 2 g/hr	Young children (30 days old–5 yrs old)	**Diazepam** 0.05–0.3 mg/kg IV to a max of 5 mg/dose or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
		Older children (4–10 yrs old)	**Atropine** 0.05 mg/kg IV/IM/IO to max 4 mg or 1 mg AtroPen and **2-PAM** 25–50 mg/kg IM or IV slowly to max 2 g/hr	Children (≥ 5 yrs old)	**Diazepam** 0.05–0.3 mg/kg IV to a max of 10 mg/dose or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
		Adolescents (≥ 10 yrs old) and adults	**Atropine** 0.05 mg/kg IV/IM/IO to max 4 mg or 2 mg AtroPen and **2-PAM** 25–50 mg/kg IM or IV slowly to max 2 g/hr	Adolescents and adults	**Diazepam** 5–10 mg up to 30 mg in 8 hr period or **Lorazepam** 0.07 mg/kg slow IV not to exceed 4 mg

2-PAM: 2-pralidoxime
IM: intramuscular
IO: intraosseous
IV: intraveneous
PDH: Pediatrics Dosage Handbook
*In general, pralidoxime should be administered as soon as possible, no longer than 36 hours after the termination of exposure. Pralidoxime can be diluted to 300 mg/mL for ease of intramuscular administration. Maintenance infusion of 2-PAM at 10–20 mg/kg/hr (max 2 g/hr) has been described. Repeat atropine as needed every 5–10 minutes until pulmonary resistance improves, secretions resolve, or dyspnea decreases in a conscious patient. Hypoxia must be corrected as soon as possible.
†Meridian Medical Technologies Inc, Bristol, Tenn.
Data sources: (1) Rotenberg JS, Newmark J. Nerve agent attacks on children: diagnosis and management. *Pediatrics*. 2003;112:648–658. (2) Pralidoxime [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2002. (3) AtropPen (atropine autoinjector) [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2004. (4) Henretig FM, Cieslak TJ, Eitzen Jr EM. Medical progress: biological and chemical terrorism. *J Pediatr*. 2002;141(3):311–326. (5) Taketomo CK, Hodding JH, Kraus DM. *American Pharmacists Association: Pediatric Dosage Handbook*. 13th ed. Hudson, Ohio; Lexi-Comp Inc: 2006.

TABLE 21-4

MANAGEMENT OF SEVERE NERVE AGENT EXPOSURE

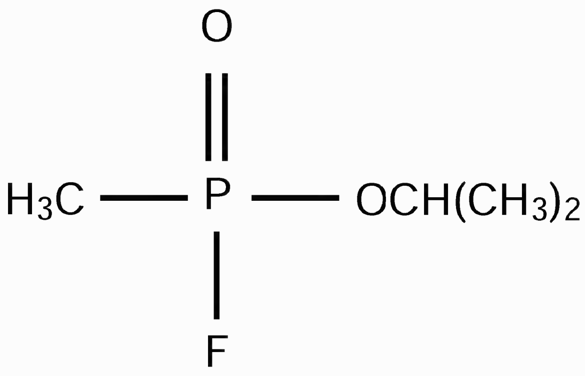
		Management			
		Antidotes*		Benzodiazepines (if neurological signs)	
Nerve Agents	Severe Symptoms	Age	Dose	Age	Dose
• Tabun • Sarin • Cyclosarin • Soman • VX	• Convulsions • Loss of consciousness • Apnea • Flaccid paralysis • Cardio-pulmonary arrest • Strange and confused behavior • Severe difficulty breathing • Involuntary urination and defecation	Neonates and infants up to 6 months old	**Atropine** 0.1 mg/kg IM/IV/IO or 3 doses of 0.25mg AtroPen[†] (administer in rapid succession) and **2-PAM** 25 mg/kg IM or IV slowly, or 1 Mark I[†] kit (atropine and 2-PAM) if no other options exist	Neonates	**Diazepam** 0.1–0.3 mg/kg/dose IV to a max dose of 2 mg, or **Lorazepam** 0.05 mg/kg slow IV
		Young children (6 months old–4 yrs old)	**Atropine** 0.1 mg/kg IV/IM/IO or 3 doses of 0.5mg AtroPen (administer in rapid succession) and **2-PAM** 25–50 mg/kg IM or IV slowly, or 1 Mark I kit (atropine and 2-PAM) if no other options exist	Young children (30 days old–5 yrs and adults	**Diazepam** 0.05–0.3 mg/kg IV to a max of 5 mg/dose, or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
		Older children (4–10 yrs old)	**Atropine** 0.1 mg/kg IV/IM/IO or 3 doses of 1mg AtroPen (administer in rapid succession) and **2-PAM** 25–50 mg/kg IM or IV slowly, 1 Mark I kit (atropine and 2-PAM) up to age 7, 2 Mark I kits for ages > 7–10 yrs	Children (≥ 5 yrs old)	**Diazepam** 0.05-0.3 mg/kg IV to a max of 10 mg/dose, or **Lorazepam** 0.1 mg/kg slow IV not to exceed 4 mg
		Adolescents (≥ 10 yrs old) and adults	**Atropine** 6 mg IM or 3 doses of 2 mg AtroPen (administer in rapid succession) and **2-PAM** 1800 mg IV/IM/IO, or 2 Mark I kits (atropine and 2-PAM) up to age 14, 3 Mark I kits for ages ≥ 14 yrs	Adolescents and adults	**Diazepam** 5–10 mg up to 30 mg in 8-hr period, or **Lorazepam** 0.07 mg/kg slow IV not to exceed 4 mg

IM: intramuscular
IO: intraosseous
IV: intravenous

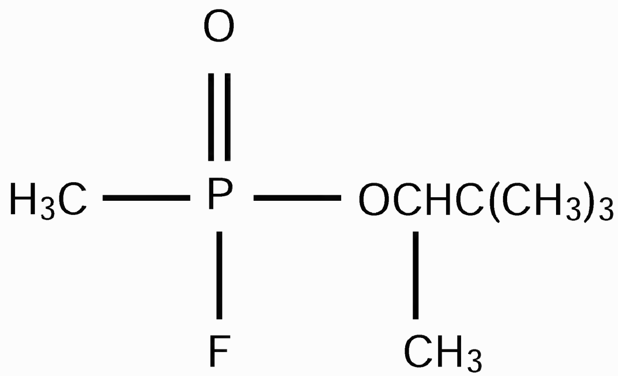
*In general, pralidoxime should be administered as soon as possible, no longer than 36 hours after the termination of exposure. Pralidoxime can be diluted to 300 mg/mL for ease of intramuscular administration. Maintenance infusion of 2-PAM at 10–20 mg/kg/hr (max 2 g/hr) has been described. Repeat atropine as needed every 5–10 min until pulmonary resistance improves, secretions resolve, or dyspnea decreases in a conscious patient. Hypoxia must be corrected as soon as possible. [†]Meridian Medical Technologies Inc, Bristol, Tenn.

Data sources: (1) Rotenberg JS, Newmark J. Nerve agent attacks on children: diagnosis and management. *Pediatrics*. 2003;112:648–658. (2) Pralidoxime [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2002. (3) AtroPen (atropine autoinjector) [package insert]. Bristol, Tenn: Meridian Medical Technologies, Inc; 2004. (4) Henretig FM, Cieslak TJ, Eitzen Jr EM. Medical progress: biological and chemical terrorism. *J Pediatr*. 2002;141(3):311–326. (5) Taketomo CK, Hodding JH, Kraus DM. *American Pharmacists Association: Pediatric Dosage Handbook*. 13th ed. Hudson, Ohio: Lexi-Comp Inc; 2006.

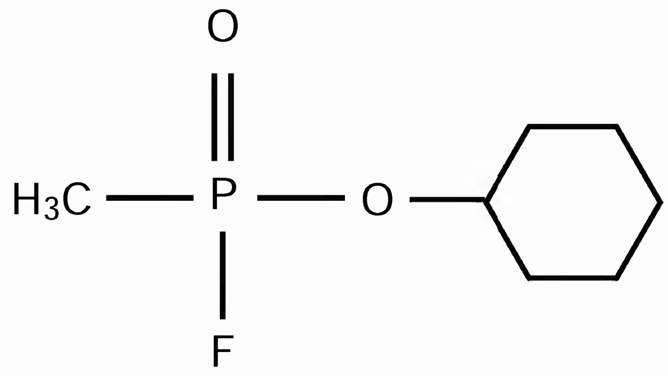
Sarin (GB)



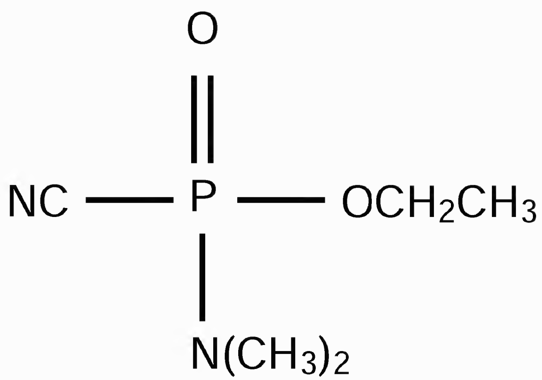
Soman (GD)



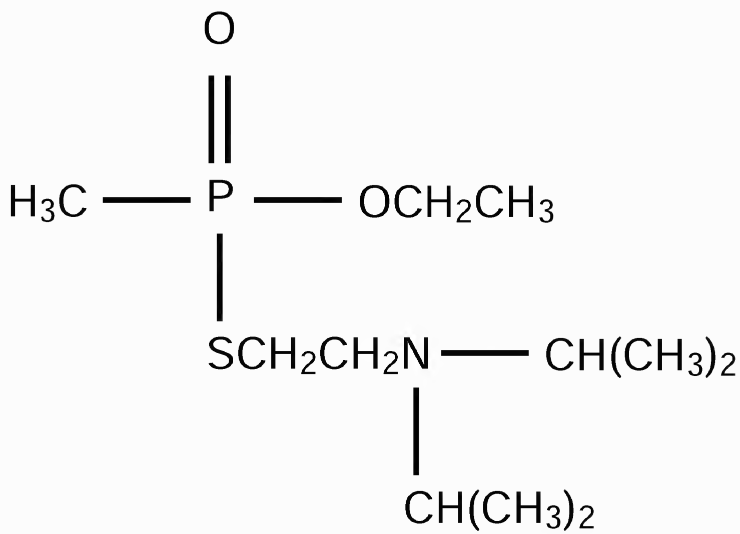
Cyclosarin (GF)



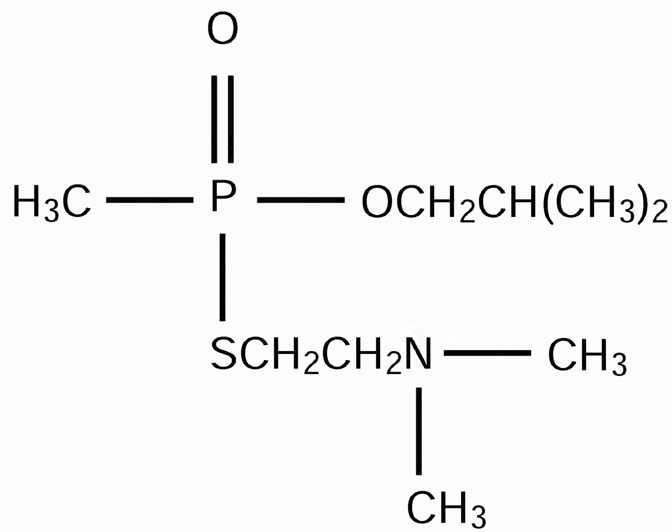
Tabun (GA)



VX



Russian VX



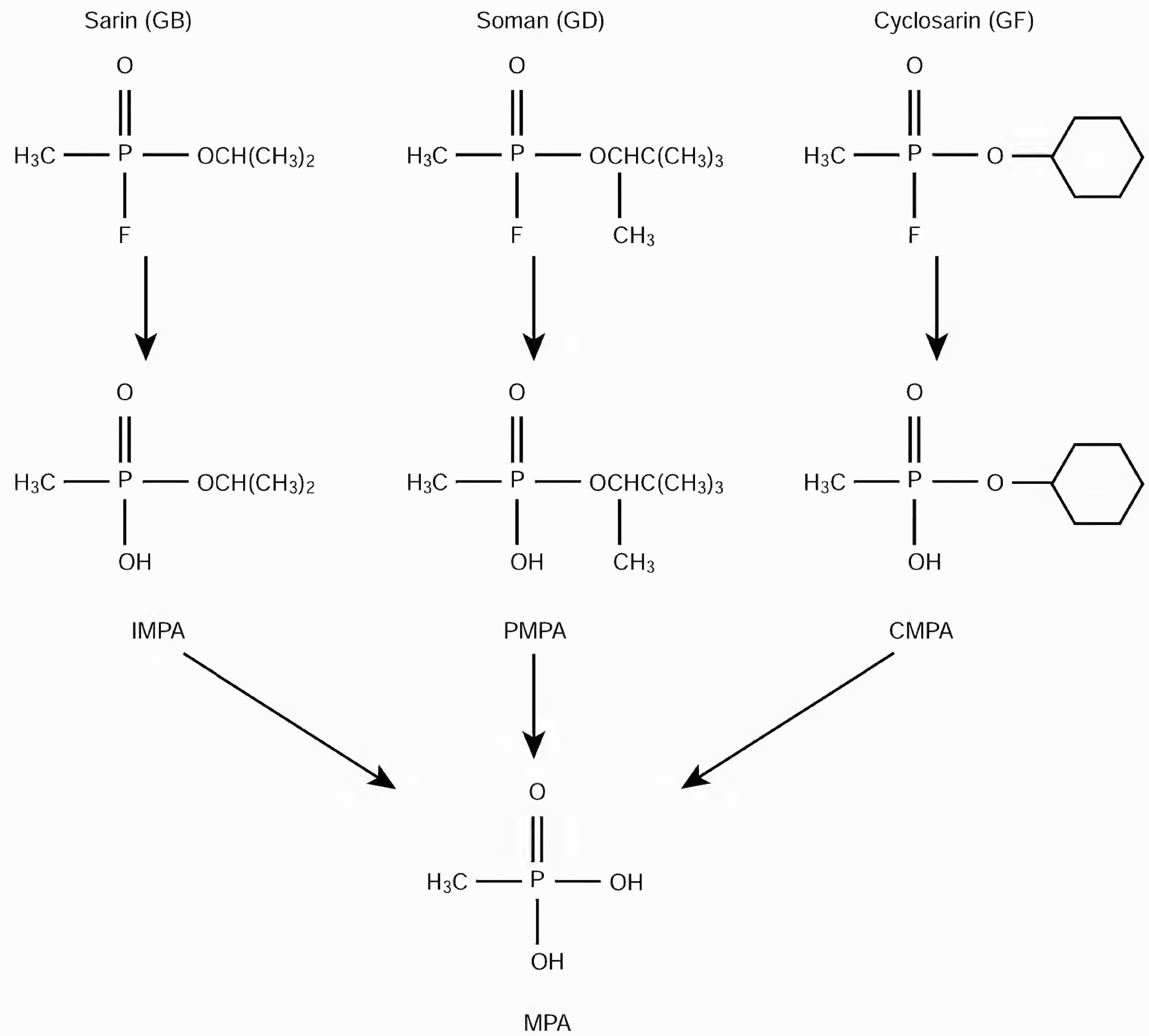


Fig. 22-2. Hydrolysis pathway of sarin (GB), soman (GD), and cyclosarin (GF). Hydrolysis pathway of nerve agents proceeds through the alkyl methylphosphonic acids IMPA, PMPA, and CMPA to MPA. Analysis of the alkyl methylphosphonic acids allows identification of the parent agent, while assay of MPA is nonspecific.
CMPA: cyclohexyl methylphosphonic acid
IMPA: isopropyl methylphosphonic acid
MPA: methylphosphonic acid
PMPA: pinacolyl methylphosphonic acid

TECHNICAL MANUAL No. 3–400
TECHNICAL ORDER No. 11C2–1–1

DEPARTMENTS OF THE ARMY AND THE AIR FORCE
WASHINGTON 25, D. C., *8 May 1957*

CHEMICAL BOMBS AND CLUSTERS

* This manual supersedes TM 3–400, 28 April 1953.

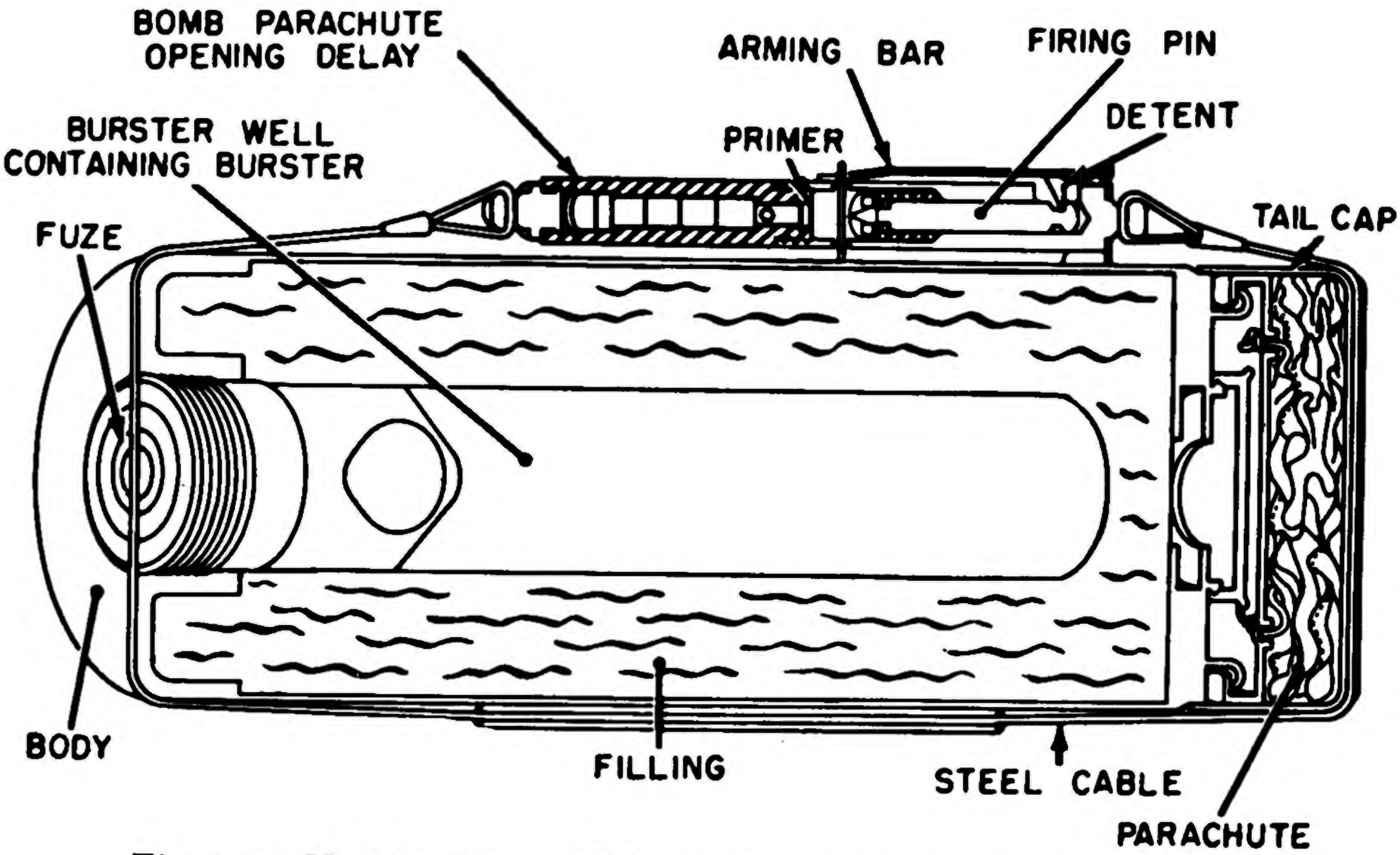


Figure 24. M125A1 10-pound GB nonpersistent gas bomb, sectional view.

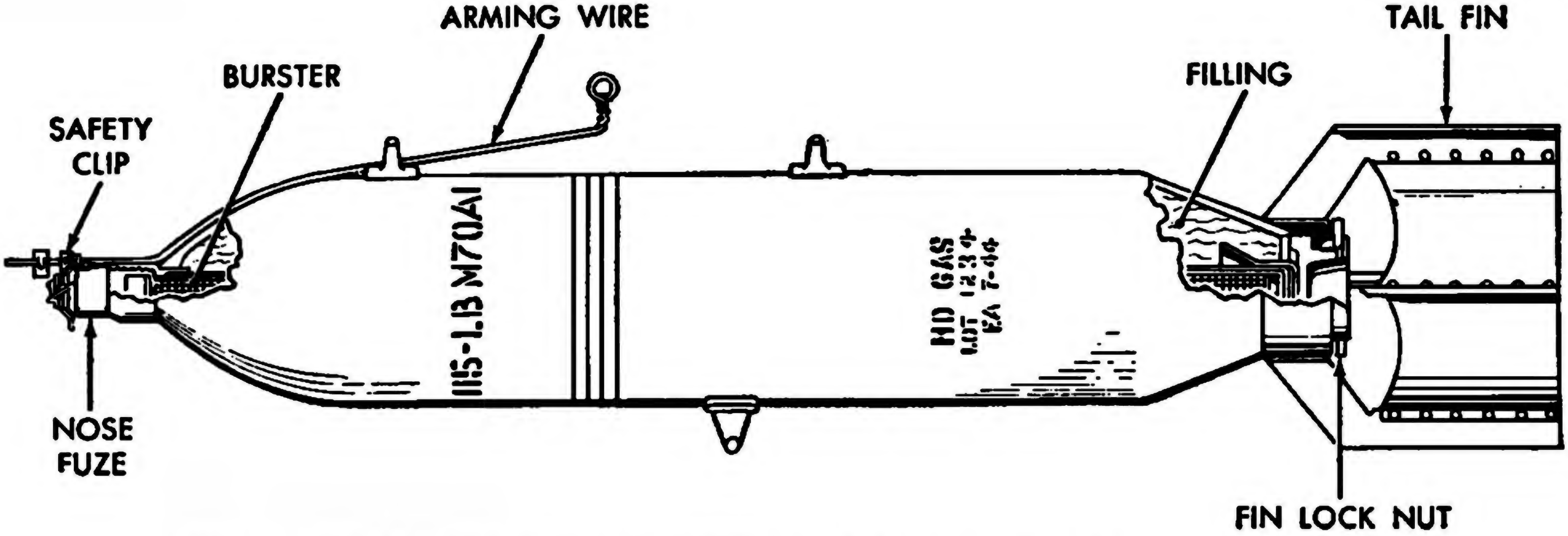


Figure 26. M70A1 115-pound HD persistent gas bomb, cutaway view.

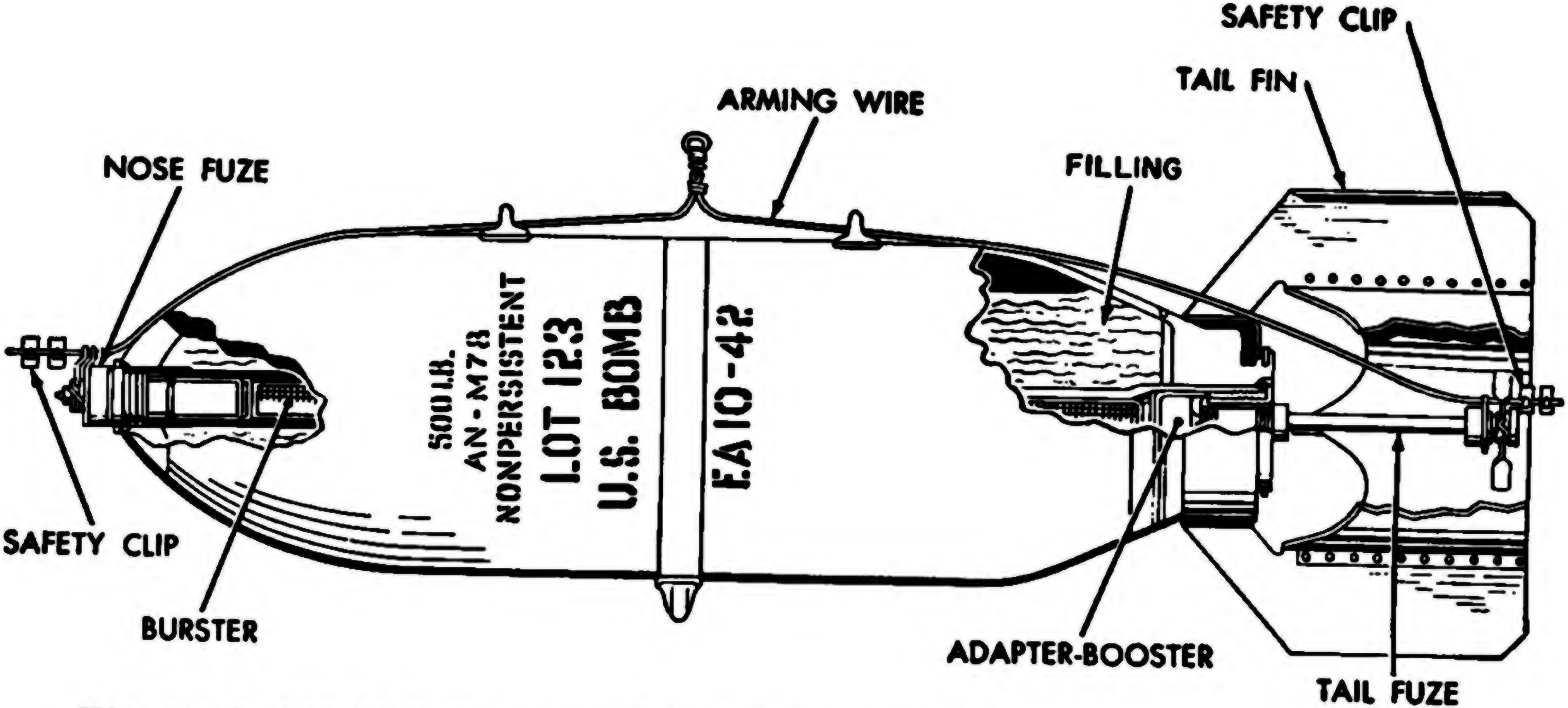


Figure 28. AN–M78 500-pound CG or CK nonpersistent gas bomb, cutaway view.

M139 (E130R2) bomblet.

The 762-millimeter M190 Honest John GB warhead. Developed as the E19R2, it carried 356 115-millimeter M134 (E130R1) spherical bomblets. The overall fill efficiency of the M190 was 37%. Range 8.5-33.8 km, bomblets released at 5 kft altitude to give a 1 km diameter area coverage.

Reid Kirby, "The CB Battlefield Legacy", Army Chemical Review, July–December 2006, pp. 25-29.

It may be several weeks or even months before I shall ask you to drench Germany with poison gas, and if we do it, let us do it one hundred per cent. In the meanwhile, I want the matter to be studied in cold blood by sensible people and not by that particular set of psalm-singing uninformed defeatists which one runs across now here, now there (Churchill 1944).

Gilbert M (1991). *Churchill. A Life*, pp. 782–783. London: Heinemann.